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ELEMENTAL ANALYSES ON ILKHANID PERIOD COINS BY PIXE: A CASE STUDY ON KING GHAZAN SILVER COINS

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ABSTRACT

After mongols second invasion to Iran by Holako (1253 AD) some political and cultural vicissitudes occurred and these events could be observed on coins. These changes included the Caliph's name elimination from coins in prior dynasties (e.g. Seljuks'). In the Ilkhanid period (1256-1336 AD) title of kings were written in Uighur language on coins while at end of this period the names and titles were written in Persian. Here, 16 silver coins belonging to Ghazan, an Ilkhanid King, were analyzed by PIXE system. Regarding compositional elements that reflects minting conditions and states in Ghazana's reign period. The silver presence varied between ~68– 93%, while the high rates of copper deliberately added, implies political and economical exigencies.

KEYWORDS: Silver, Ilkhanid, PIXE, Coin, Metal, Iran

1. INTRODUCTION

Nowadays, non-destructive techniques such as PIXE, XRF, and others are used in numismatic studies for elemental composition identification (Liritzis & Zacharias, 2011). Chemical analysis of coins provides useful information about metallurgical techniques, as well as, political and economical conditions and states of the minting time (Vijayan & Choudhury, 2004).

In numismatic studies, the determination of the concentration of gold(Au) level is very important because the high level of Au in silver objects could sometimes be a sign of used silver ore (Meyers et al., 1976). High concentrations of Au in silver coinsmay be an indication of external origin of Ag. High levels of Pb in silver coins indicate that galena ore type was used in minting of silver coins (Flament & Marchetti, 2004).The negative correlation between Cu and Agmeans that Ag was substituted by Cu (Uzonyi et al, 2000).

In this study, sixteen silver coins belonging to Ghazan's reign period (1295-1304) were analyzed by PIXE technique. These coins, with regard to their epigraph on them, belong to Ghazan Khan and were minted in Astarabad (a city in North of Iran) mint house (Plate 1).

The aim of this research is to study the elemental compositions of coins, to clarify the conditions and states of the coinage in Ilkhanid kings era and to check the compatibility of the results with the historicalevidences and sources about this era. The results of this study can be seen in Table 1.

2. HISTORICAL BACKGROUND

Ilkhanid dynasty was established by Holako Khan in 1256and its last king was Mosa Khan (1336). In this period several Khan (a title used for Mongolian Kings), who were stooges of Amir Hussein Bozorg Jalaieri and Amir Hasan Kochak Chopan, succeeded to throne.

Finally, after a chaos that happened during Anushirvans reign the Jalaiery clan became independent and Ilkhanid dynasty collapsed and Iran cleaved between local dynasties such as Jalaierian and Ale Mozaf'far.

When Ilkhans took the power and established their dominion in Iran some changes occurred and these changes are visible on coins. From these changes, the elimination of Caliph's name from coins, which was due to the downfall of Abbasid dynasty and writing on coins by Uighur's language, could be mentioned.

Mongols invasion to Iran brought about great disasters; in addition to that, Ilkhanid kings and regent's pecuniary policies and conditions led to an economical infirmity in Iran.

Ghazan was one of greatest kings of Ilkhans that during his reign (1295-1304) some reforms were conducted, for economical reconstruction such as reviving money circuit system, establishing a fixed rate for silver coins (a coins had an average weight about 13.6 gr) and forming a weighting system unit and scale for all over the territory.

Although these reforms led to a relative economical improvement, this was not significant because of high rates of taxes (Boyle, 1968: 467-470).

3. MATERIAL AND METHODS

Sample Preparation

Silver coins of Ilkhanid which were kept in private collections were measured by PIXE. Coins have been cleaned by acetone and distilled water, after that they were kept in open air for 24 hours to get dry. Later the samples were sent to Van de Graff laboratory for analysis. The weight of coins varied between 1.65 and 3.94 grams.

Experimental setup

A 2 MeV proton beam with a current of 2-3 nA from AEOI, Van der Graff accelerator was used to bombard the coins. A multipurpose scattering chamber with 12 inch diameter was used.

The beam size at the target position was 2 mm^2. The beam direction and the characteristic X-rays emitted from the samples were detected by an ORTEC Si (Li) detector (FWHM 170 eV at 5.9 keV) at 45°. Each target was run for 2 minute approximately.

The typical spectrum of one silver coin is shown in Fig 1.

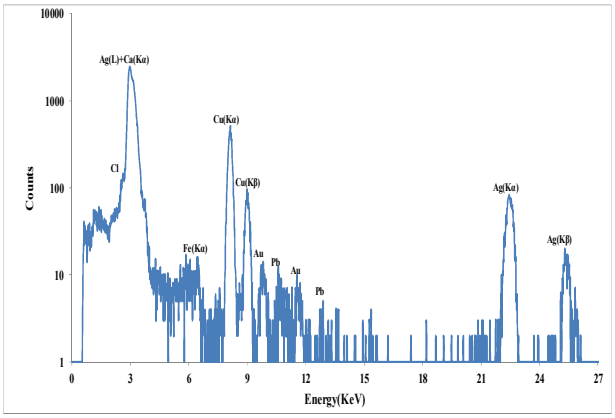

Figure 1: Typical PIXE spectrum of coin No. 5, of Ilkhanid period.

The vacuum obtained inside the experimental chamber was of the order of 10-5Torr. To detect light and heavy trace elements simultaneously, a funny filter (a 175 lm Mylar with a hole drilled at its Centre, placed in front of the detector window) has been used as absorber.

The GUPIX software was employed to analyze the obtained spectra. The results are shown in Table 1. In this study, the standard Merck Art.2700 was used to calibrate. Overall uncertainty for the PIXE method was 5% for major elements; 5-10% for minor elements and 15% for trace elements.

Table 1: Percentage concentration (%) of present elements in the Ilkhanid coin by PIXE.

Weight	Pb	Au	Ag	Zn	Cu	Fe	Ca	Cl	Si	Sample
3.02	0.61±0.1	1.01±0.1	79.54±3.9	-	17.31±0.8	-	0.64±0.1	0.89±0.1	-	1
1.94	1.18±0.1	1.09±0.1	68.33±3.4	-	27.24±1.3	-	0.71±0.1	1.45±0.1	-	2
2.23	1.43±0.1	0.96±0.1	80.35±4.0	-	15.82±0.8	-	0.77±0.1	0.67±0.1	-	3
2.73	1.23±0.1	0.72±0.1	87.78±4.3	-	8.08±0.8	-	0.93±0.1	0.89±0.1	0.37±0.0	4
3.94	0.41±0.0	0.85±0.1	88.91±4.4	-	8.06±0.8	0.08±0.0	0.96±0.1	0.73±0.1	-	5
2.84	1.24±0.1	0.92±0.1	88.43±4.4	-	7.27±0.7	-	1.12±0.1	1.02±0.1	-	6
3.19	0.6±0.0	1.12±0.1	87.06±4.3	-	9.06±0.9	-	0.85±0.1	1.31±0.1	-	7
1.65	1.5±0.2	0.85±0.1	88.4±4.4	0.16±0.0	7.15±0.7	-	0.93±0.1	1.01±0.1	-	8
3.49	0.26±0.0	0.84±0.1	93.15±4.6	-	4.16±0.4	-	0.88±0.1	0.71±0.1	-	9
2.84	0.8±0.0	1.02±0.1	89.07±4.4	-	6.99±0.7	-	1.09±0.1	1.03±0.1	-	10
3.08	0.82±0.1	1.07±0.1	82.23±4.1	-	14.61±0.7	-	0.75±0.1	0.52±0.1	-	11
3.57	0.88±0.1	0.58±0.1	88.76±4.4	-	7.78±0.8	-	0.93±0.1	1.07±0.1	-	12
3.20	1.68±0.3	0.67±0.1	82.47±4.1	-	13.16±0.6	-	0.97±0.1	1.05±0.1	-	13
3.34	0.59±0.1	1.3±0.1	86.08±4.3	-	9.95±0.1	-	0.95±0.1	1.13±0.1	-	14
2.27	1.38±0.1	0.98±0.1	77.16±3.8	-	18.9±0.9	-	0.77±0.1	0.81±0.1	-	15
2.59	0.51±0.1	1.2±0.1	90.67±4.5	-	5.79±0.6	-	0.88±0.1	0.71±0.1	0.24±0.0	16

4. RESULTS AND DISCUSSION

The coins analysis identified elements which include Ag, Au, Pb, Cu, Fe, Cl, Ca, Si and Zn (Table 1). The amount of Ag in coins varied between ~68 – 93% with an average of 84.96%. The variations in the concentration of Ag across these coins are relatively high and it could be the result of economical weakness in this period. With regard to the idea that Au is an indicator of silver source (Meyers et al, 1976), Fig 2 shows that the sources of silver used for coins number 2, 12 and 14 are different from the other coins.

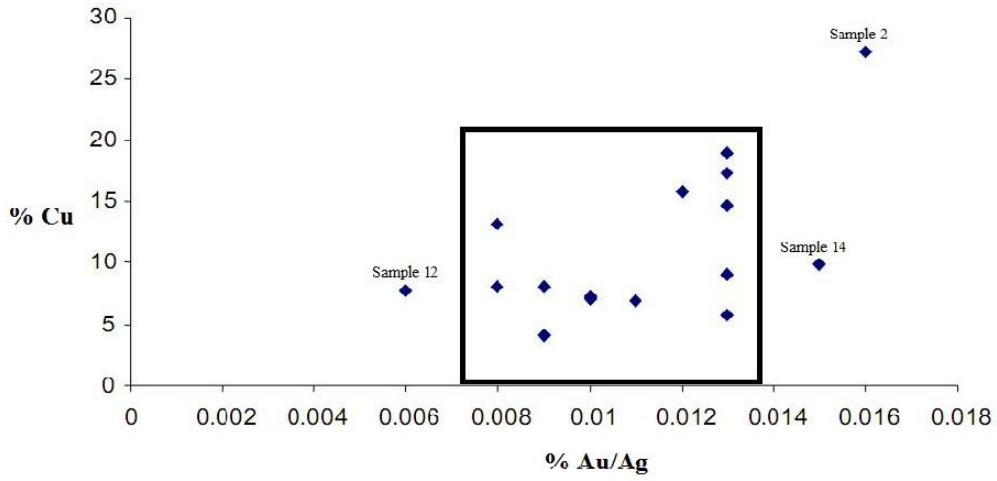

Figure 2: The percentage of Au/Ag and Cu in the analyzed coins by PIXE

The amount of Cu varied from 4.16 to 27.24%. The high level of Cu hardening and also political and economic reasons (Tripathyet al., 2010) (Table 1). The low ratio of Fe, only in coin number 5, is attributed to external pollution with dust incrusted at the surface of the coin (Hajivalieiet al, 2008). High levels of Pb indicate usage of Pb and Zn mines in minting process (Uzonyiet al. 2000); With regards toPb which is an indicator of the technological level of purifying processes; concentration of less than 1% of Pbin some of the coins isan indicator of good techniques used in silver refining processes (Kantarelou et al., 2011).

5. CONCLUSION

A collection of silver coins belonging to the same King, which were minted in one place were selected and studied in order to investigate the minting conditions of Ghazan, an Ilkanid King period, and to check the compatibility of the results with historical resources and information,. According to written sourcesfrom Ilkhanid period, the country's economic situation was not good; despite the reforms which were conducted for improving the economic situation by Ghazan.

The weak economic and government conditions of this period can be seen in coins carat. However, regarding the fact that changes in the concentration of silver in these coins are relatively large fluctuations, it may be the case thatthe coins with low rate of Ag were minted in the early time of Ghazansreign orbeforehis economic reformsand coins with high rate of Ag belonged to a time after his reforms, but because of Illegibility of minting time on coins (in some case the date become vague because of corroded surface of coins and in other samples this date wasn't scribed), commenting on this issue cannot be definitive.

Plate 1: Both sides of Ghazan coins used in the study

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