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ELEMENTAL COMPARISON OF SILVER COINS OF IRANIAN SELJUK WITH THOSE OF ROMAN EMPIRE BY PIXE

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ABSTRACT

Elemental analyses of silver coins provide valuable information about political and economical situation and also about the mines and metallurgy of minting time. The variation of the elemental concentration may be due to the use of different ores for making coins. In this research nine silver coins belonging to Anatolian Seljuk's along with five silver coins belonging to Iranian Seljuk's were analyze by PIXE. The Elements discovered in the coins include: Ag, Au, Pb, Cu, Fe, Ca, Si, Cl, Ti, and Bi. The comparison between Ag rates in these coins revealed that rate of Ag in Roman Seljuk's coins is more than Ag rate in that of Iranian Great Seljuk's. This may indicate a higher level of technique used by Roman Seljuk for extracting silver and issuing coins. High rate of Cu in both Roman and Iranian coins showed that these high rates were deliberately added. Finally, the same amount of Lead used in both types of coins is due to similar technology used for extracting silver from Lead and Zinc ores.

KEYWORDS: Seljuk, silver, metal, coin, PIXE

1. INTRODUCTION

Elemental analysis of Metals provides valuable information about the composition of alloys and sometimes may lead to identifying the Metals origins (Guerra *et al*, 2008). In numismatics, the determination of the original alloys composition is important to know the genuine fineness of the coins. Relative proportion of main elements in coins provides significant information about monetary system changes, economic and political conditions and debasement technology (Beck *et al*, 2004).

In this study, PIXE technique was used as a non-destructive analysis. In silver coins density of Ag, Cu and Pb depends on used silver ores and metallurgy (Tripathy *et al*, 2010). Silver coins analysis showed that Au concentration could be an indicator of used silver ores (Uzonyi *et al*, 2000).

Therefore, examining the ratio between Au and Ag gives useful information about silver ores is extracted (Flament & Marchetti, 2004). High ratio of Au, Pb and Bi in silver objects reveals that the used ore is from Cerussite type (Meyers *et al*, 1975).

Continuing previous studies on Roman Seljuk's silver coins (Masjedi *et al*, in press) in this study, in addition nine more silver coins belonging to Roman Seljuk's (Key Kubad II, Key Kavus II, Kilij Arsalan III and IIII), and five other silver coins belonging to Iranian Great Seljuk's (Toghrol and Sanjar) were analyzed by PIXE (Plate 1.2). Results are shown in Table 1&2. Elemental comparison between silver coins of the two dynasties was done in order to gain a better understanding of the economical and political conditions in those periods.

2 HISTORICAL BACKGROUND

Seljuk's Empire Seljuk was established in under the leadership of Toghrol (1037 AD). After Bar-Kiaroqs reign (1104 AD) the Seljuk's realm ruptured and some tributary branches emerged, but the main branch of this dynasty until Sanjar's death was namely recognized as the boss of all Seljuk's branches and he was the last king of Great Seljuk's. Toghrol's name is registered on minted coins in Marv and Baghdad. In minted coins in Baghdad Caliph's name is registered too.

Kings after Toghrol couldn't write their glorious titles on coins that were minted in Baghdad; because only the caliph could permit them to do it, in other regions (except Baghdad) the king was free to write any title on the coins (Safi, 2006:36-42).

The Roman Seljuk's were a branch of Seljuk's empire that established their government in some parts of Asia Minor between 5-8 centuries. The founder of this Seljuk dynasty was Suleiman Ibn kutlumush and its last King was Kiath al-din Masoud III.

It was only under Danishmendid Samushtegin Ghazi and probably after him, the Seljukid Masud first that the Seljuk Turks minted coins. The issuing and minting of silver coins was very common during Kilij Arsalan II era (Cahen, 1968: 56-68).

In beginning of Seljuk government coins having Greek portraits on them were very common. These coins were minted in Konya (Pamuk 2002). After the Turks attacked Asia Minor, A large quantity of Byzantine coins, especially silver and gold coins, were melted by Kilij Arsalan II and were again used in minting new coins.

In this research nine silver coins belonging to Anatolian Seljuk's along with five silver coins belonging to Iranian Seljuk's were analyze by PIXE.

3. GEOGRAPHY OF UNDER STUDY AREA

The apogee of Seljuk's power was under the reign of Alp Arsalan and Malekshah. Their most important centers include: Marv, Nishapur, Rey, Hamedan, Esfahan, Sajestan, Harat and Mousel (Map 1).

Sivas is a city located in east-central Turkey. The city was captured by Seljuk's

ruler the reign of Kilij Arslan II and periodically served as the capital of the Seljuk Empire along with Konya. Konya was the capital of the Anatolia Seljuk Sultanate from 1097 to 1243 AD. This city was flourished under the reign of Kay-khusraw I through to Kay-khusraw II (Lanke *et al.* 2003). (Map1). Under Seljuk's rule, Sivas was an important center of trade along the Silk Road (for more information see, Pamuk, 2000). Gumushbazar is located in the westernmost district of Amasya Province of Turkey, 20 Kilometers from the larger town of Merzifon.

Map 1: Realm of Seljuk's Empire.

4. MATERIAL AND METHODS

4.1 Samples Preparation

We selected silver coins of Iranian and Roman Seljuk's which were in a private collection. Coins were cleaned by Acetone and distilled water before submitting to the Van de Graff laboratory. The weight of coins in Roman Seljuk's' coins were between 2.39 and 3.00 grams and that of Iranian Seljuks coins were between 3.09 to 3.95 Coins were selected randomly due to the absence of coins under study in Iran. Access to other types of coins was difficult due to absence of circulation of Roman Seljuk coins in Iran.

4.2 Experimental setup

The samples were analyzed by PIXE machine. A 2 MeV proton beam with a current of 2-3 nA from AEOI, Van de 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 characteristics of the 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 minutes approximately. The typical spectrum of one silver coin is shown in Fig 1.

The vacuum obtained inside the experimental chamber was of the order of 10^{-5}Torr. 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.

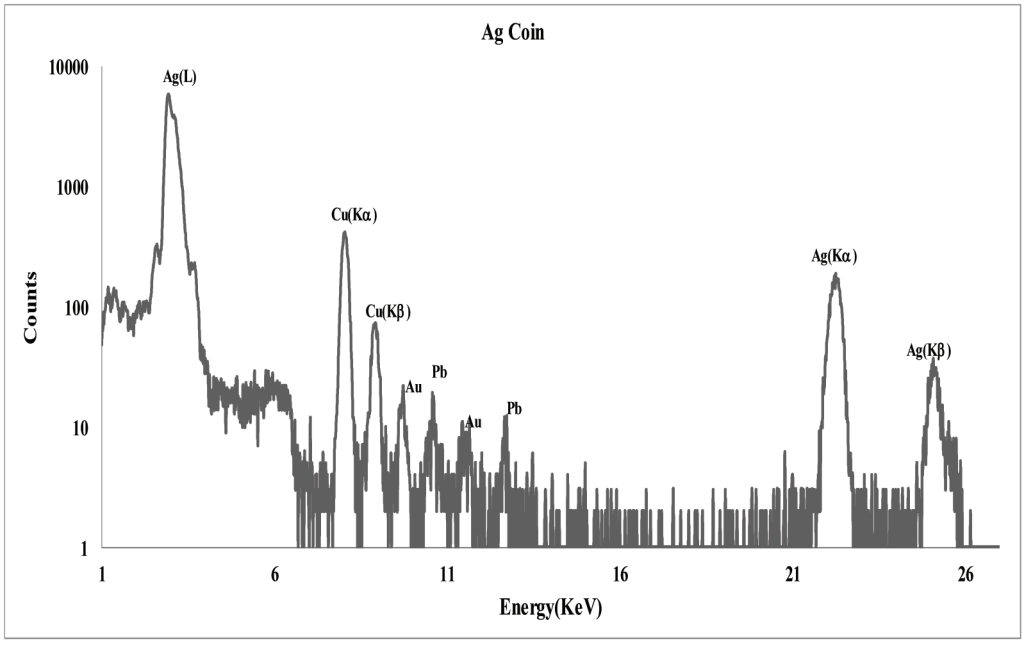

Figure 1: Typical PIXE spectrum of coin No.9 belonging to Roman Seljuk's.

5. RESULTS AND DISCUSSION

The elements measured are: Ca, Cl, Si, Pb, Cu, Bi, Au, Ag and Fe (Table 1&2). The amount of Ag in Iranian Seljuk's coins was between 80.17 to 96.33%. The amount of Ag in Roman Seljuk's Coins varied from 88.58 to 96.85 %.

The comparison between the level of Ag in Roman and Iranian Seljuk's revealed that the average of Ag in coins that were minted in Anatolia was higher than Iranian Seljuk's coins. This may be because of a higher level of technique used by Roman Seljuk's for extracting silver and issuing coins (Tripathy *et al.* 2010).

Among Roman Seljuk's silver coins, higher amounts of Ag is in coins minted in Konya which indicates good economical situation in this city. The level of Cu in Iranian Seljuk's coins is between 2.69 and 14.88 and in Roman Seljuk's varied from 1.27 to 6.83.

High level of Cu in Roman and Iranian Seljuk's coins shows that Cu was deliberately added to the coins for more stability in coins and for economical conditions as well (Tripathy *et al.* 2010).Since Au is an index of silver ore mines (Kallithrakas-Kontos *et al.* 2000), Fig 4 shows that the used ore in samples no 5, 7 & 8 of Roman Seljuk's is different from that used in others coins. Therefore, according to our results the silver ore used in coins no 2 & 4 in Iranian Seljuk's coins is different from that used in other Iranian Seljuks coins (Fig 3).

High level of lead and high level of Au are observable in coin No. 6 of Roman

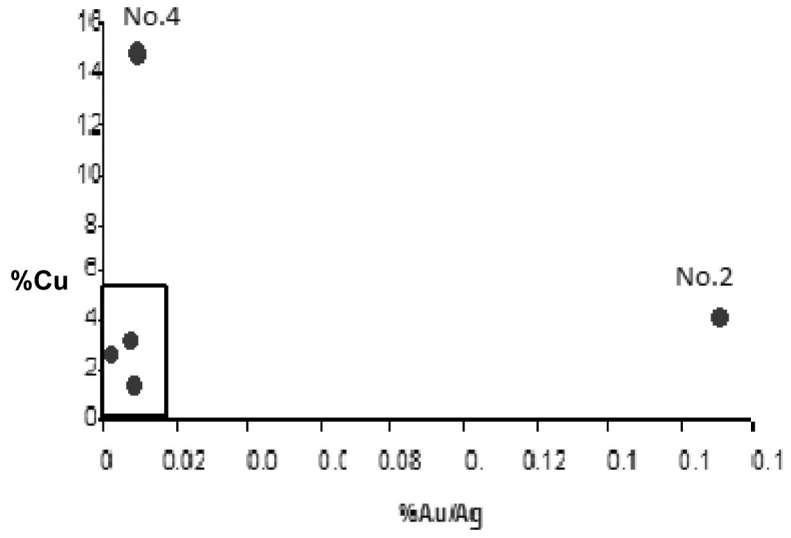

Figure 3: The percentage of Au/Ag and Cu in the analyzed Iranian Seljuk coins by PIXE.

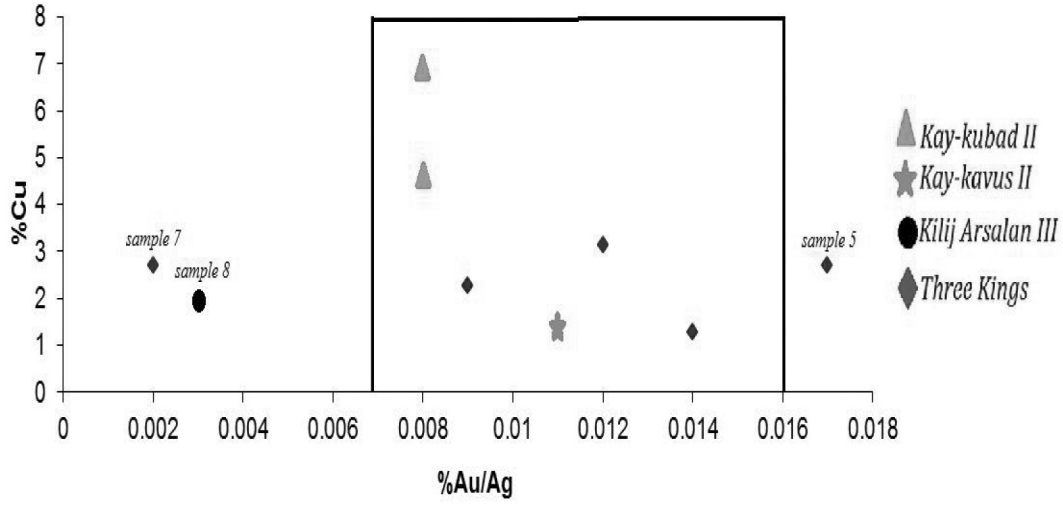

Figure 4: The percentage of Au/Ag and Cu in the analyzed Roman Seljuk coins by PIXE.

Seljuks which we assumed to be due to re-melted silver sources (Table 2), the existence of Bi can be a sign of various used mines that which this fact is seen in coins no. 5, 4 and 5 belonging to Roman Seljuks.

Low concentration of Pb in Roman and Iranian Seljuks silver coins (Fig. 5) shows a good technology for the refining process (Tripathy *et al.* 2010). On the other hand, high level of Pb concentration in some coins shows that lead and zinc mines were used in the production process of the coins (Uzonyi et al. 2000).

Our results (Table 1&2) shows certain amount of Fe in the coins and it can be due to the external pollution with dust incrusted at the surface of the coin (Flament & Marchetti, 2004). High level of Fe in coin no. 6 of Roman Seljuks shows that silver extraction from lead and zinc is associated with iron (Kantarelou et al. 2011).

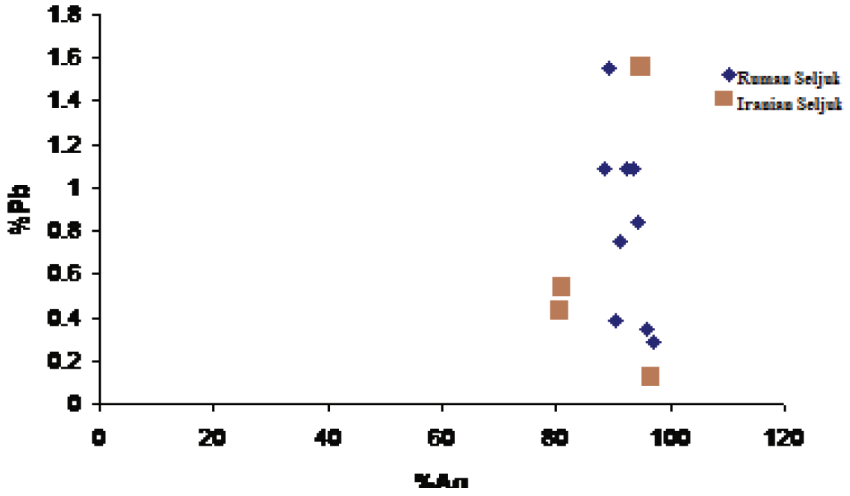

Figure 5: The percentage of Pb/Ag in the analyzed Roman Seljuk and Iranian Seljuk coins by PIXE.

6. CONCLUSION

Comparison between Iranian and Roman Seljuk's silver coins shows that Roman Seljuk's used a better technology for extraction and refining. On the other hand, high average of Ag in Roman Seljuk's coins is a sign of their good economical situation. Among minted coins in Konya, Sivas and Gumush Bazar, the coins minted in Konya have more ratio of Ag and the reason is that Konya was the capital.

High percent of Cu in Iranian and Roman Seljuk's coins indicates that this metal was added deliberately for enhancing stability because of economical and political reasons. Lack of Pb in both Iranian and Roman Seljuk's is a sign of good used technology for silver extraction from Lead and Zinc mines. Equal amount of Pb in the coins shows a similar technique used for Ag extraction from ore. The Fe identified in the coins represents a surface pollution.

Table 1: Percentage concentration (%) of present elements in the analysis of Iranian Seljuk coins by PIXE

Sample	Si	Cl	Ca	Fe	Cu	Zn	Ag	Au	Pb	king	Weight
1	0.32±0.03	0.28±0.03	0.51±0.01	-	2.69±0.3	-	94.41±4.7	0.23±0.02	1.56±0.2	Sanjar	3.23
2	-	-	0.20±0.02	-	4.11±0.4	0.09±0	81.12±4.0	13.94±0.7	0.54±0.05	Toghrol	3.09
3	-	0.33±0.03	0.91±0.1	-	1.43±0.1	-	96.33±4.8	0.88±0.1	0.12±0.01	Toghrol	3.95
4	0.84±0.08	1.80±0.2	1.02±0.1	0.05±0	14.88±0.7	-	80.17±4.0	0.80±0.1	0.44±0.04	Toghrol	3.33
5	0.32±0.03	1.40±0.1	0.94±0.1	-	3.28±0.3	-	93.29±4.6	0.77±0.1	-	Toghrol	3.62

Table 2: Percentage concentration (%) of present elements in the analysis of Roman Seljuk coins by PIXE. (zeros=calculated as zero)

Sample	Si	Cl	Ca	Ti	Fe	Cu	Ag	Au	Pb	Bi	King	Weight
1	0.00	0.51±0.1	0.82±0.1	0.00	0.00	4.50±0.5	92.36±4.6	0.72±0.1	1.09±0.1	0.00*	Kay-kubad II	2.94
2	0.00	0.62±0.1	0.89±0.1	0.00	0.00	6.83±0.7	89.36±4.5	0.75±0.1	1.55±0.2	0.00*	Kay-kubad II	2.89
3	2.06±0.2	0.90±0.1	2.51±0.3	0.00	0.62±0.1	1.27±0.1	90.25±4.5	1.29±0.1	0.39±0*	0.71±0.1	Three Kings	2.85
4	0.26±0.03	0.67±0.1	1.14±0.1	0.00	0.00	2.28±0.2	93.62±4.7	0.89±0.1	0.82±0.1	0.32±0*	Three Kings	2.50
5	0.54±0.05	0.76±0.1	0.92±0.1	0.00	0.07±0.1	2.70±0.3	91.37±4.5	1.59±0,2	0.74±0.1	1.3±0.1	Three Kings	2.39
6	2.01±0.2	0.64±0.1	1.1±0.1	0.06±0	2.32±0.2	3.14±0.3	88.58±4.4	1.06±0,1	1.09±0.1	0.00*	Three Kings	3.00
7	0.61±0.06	0.62±0.1	1.01±0.1	0.00	0.03±0.0	2.71±0.3	93.69±4.7	0.24±0	1.09±0.1	0.00*	Three Kings	2.88
8	0.00	0.00	0.58±0.1	0.00	0.00	1.94±0.2	96.85±4.8	0.34±0	0.29±0*	0.00*	Kilij ArsalanIII	2.85
9	0.24±0.03	0.72±0.1	0.40±0	0.00	0.06±0.0	1.38±0.1	96.00±4.8	1.09±0.1	0.35±0*	0.00*	Kay-kavusII	2.80

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