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ELEMENTAL ANALYSIS OF SILVER COINS OF SELJUK'S' OF ROME BY PIXE: A CASE STUDY

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ABSTRACT

Elemental analysis of silver coins provides valuable information regarding mines and mint houses which coins has been minted for circulation. Additionally, the analysis will yield information about the political and economical conditions among the coins have been circulated among the cities which the coins have been issued.

Several silver coins belonging to Roman Seljuk which has been ruled in Anatolia have been analyzed for the first time by using multi-elemental non-destructive PIXE technique.

Our studies reveals that silver, copper, Iron, gold and lead are the major, minor and trace elements as key elements in the PIXE technique and distinguishing of mint houses. Average of Ag in coins showed higher amount of Ag is in coins minted in Konya which indicates a good stability and economic situation at this city. High concentration of Cu in coins indicates that, it has been added deliberately to show monetary policy or economic necessity.

KEYWORDS: Metal, Silver, Coin, Roman Seljuk, PIXE.

INTRODUCTION

The chemical composition of coins can give information on the fineness of coin and chemical elements presented in them as well as the political and economical condition.

Nowadays numismatics alone cannot answer all relevant questions imposed regarding coins(e.g. faking, provenance), and the application of scientific methods to study chemical compounds of coins may gave result for better understanding of politico economic of this kingdom. Indeed, the determination of the origin of alloys composition is helpful to determine the genuine fineness of the coins is most needed (Tripathy et al, 2010).

The advance of non-destructive techniques in the sixties was synonymous with great changes in metallic analysis applied to numismatics (Flament & Marchetti, 2004). Elemental analysis of coins provides valuable information on metallurgy of minting time, metal sources, and changes in monetary system, political and economic conditions (Tripathy et al, 2010). The proton induced X-ray emission (PIXE) is non-destructive, multi-elemental and a fast technique; therefore, a large number of objects can be analyzed (Hajivaliei et al, 2008).

Analysis of silver coins shows that concentration of gold can be indicative of the silver bearing ore used (Meyers et al, 1976). High gold contents, high lead levels, and high bismuth levels in silver artifacts indicate that the ore type used is of cerussite type (Meyers et al, 1976). In this research nine silver coins belonging to Seljuk of Rome were analyzed by PIXE technique (see, Plate 1)

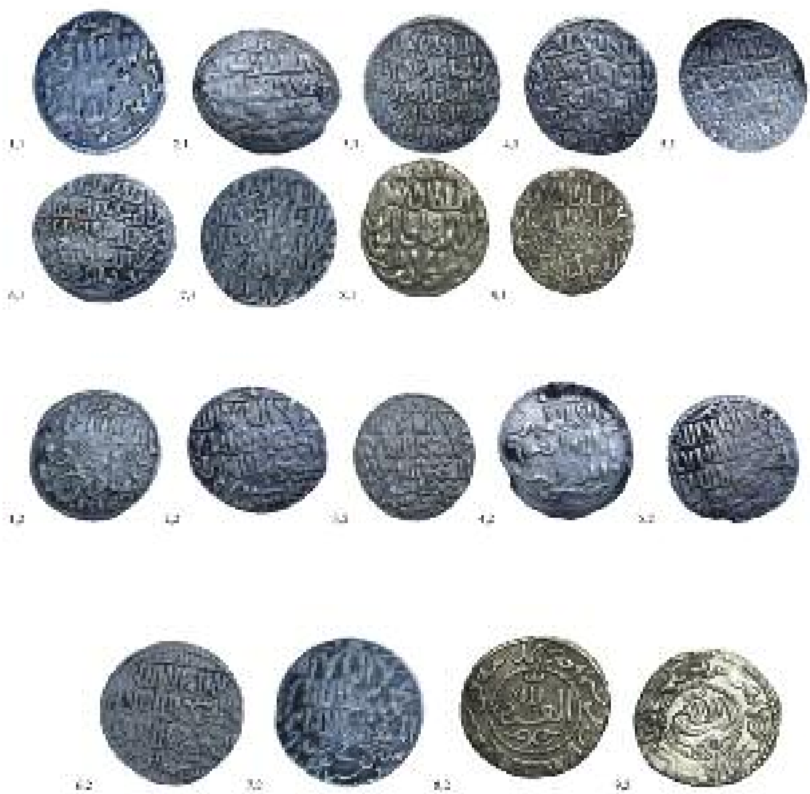


Plate 1: Both sides of silver coins used in the study

Two coins belong to Ala al-Din Kay-kubad II Ibn Kay-khusraw I (1236-1246 AD) and five coins belong to three kings KilijArsalan IIII, Kay-kavus II and Kay-kubad II (1245-1256 AD) (KilijArsalan III, Kay-kavus II & Kay-kubad II were sons of Kay-khusraw II 1236-1246 AD), one coin belong to KilijArsalan III (1201 AD) and one coins belong to Kay-kavus II Ibn Kay Khusraw II (1217-1235 AD). Their names on the coins and place of mint has been engraved. Coins have mint in Konya, Sivas and Gumush-bazar. The weight of coins varied between 2.39 till 3 gr.

Several sources of silver (Jesus, 1978; Yener, 1986) have been reported in Anatolia from ancient time and possibly were used in the time of Roman Seljuks. Several works has been done on the coins analysis at Austria by EDXRF and SEM/EDX techniques and they have been used to find concentration of gold and bismuth to distinguish between medieval period mint houses (Linke et al, 2003). At any rate, due to unknown sources of ores, we cannot find the provenance of metal even in one of the mint houses (Rehren & Pernicka 2008). Possibly additional lead is the indication of refining lead extraction from galena (Flament & Marchetti, 2004). But with high level of gold and low level of lead, it is assumed that re melting has been issued with foreign silver. In another work, tin, gold and antimony have been used for distinguishing of mint house by several spectroscopy methods (Guerra, 2004).

The aim of this research was to survey chemical composition of silver coins in order to understand the silver source used and economic position in that period. In this research, nine coins belonging to Seljuk's of Rome were studied by PIXE as a case study (see above, Plate 1). The results of this study are shown in Table 1.

HISTORICAL BACKGROUND

The Rome Seljuk was a branch of Seljuk tribes which dominated over Iran, some parts of Iraq, and the eastern part of Turkey. The founder of this dynasty of Seljuk who was a branch of Iranian Great Seljuk was Suleiman Ibn kutlumush and its last King was Kiath al-din Masoud II.

Roman Seljuk rulers began to mint silver coins in their capital city Konya and Kayseri in closing years of the twelfth century which later became coins of Ottoman. It seems, Turks Tribes in Asia Minor before the establishment of the Turkish state of Asia Minor hadn't mint house. It is only under Danishmendid Samushtegin Ghazi and probably after him, the Seljukid Masud first minted coins. The issuing and minting of silver coins were by KilijArsalan II. However, there are Greek legends belonging to early Seljuk coins and early issues had the mint house in the name Konya (Pamuk 2002) and their raids in Asia minor has caused large quantity of Byzantine coins and some of these coins were re-melted; especially silver and gold coins of Byzantine in the earlier stage of issuing coins from KilijArsalan II silver coins and again re-issued.

The Roman Seljuk's' coins under study weighted between 2.39 and 3 gr. Coins were from Kay-kubad II Ibn Kay-khusraw I, Kay-kavus II Ibn Kay-khusraw II, kilijArsalan III and five coins belong to Kay-kavus II, Kilij Arsalan III and Kay-kubad II period (during their common reign period), and were minted in Konya, Sivas and Gumushbazar.

GEOGRAPHY OF SITE UNDER STUDY

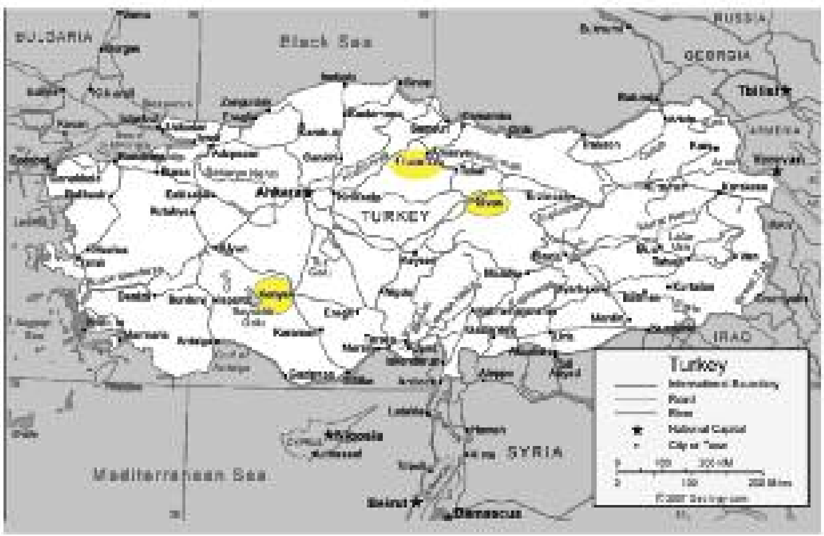
The apogee of Seljuk government in Anatolia was during the thirteenth Century and their Capital was in Konya. This city was flourished under the reign of Kay-khusraw I through to Kay-khusraw II (Lanke et al, 2003).

Sivas is a city in east-central Turkey; the city was captured by Seljuk ruler Kilij Arslan II and periodically served as the capital of the Seljuk Empire along with Konya.

Konya was the capital of the Rome Seljuk Sultanate from 1097 to 1243 AD (Map 1). Under Seljuk rule, Sivas was an important center of trade along the Silk Road (for more information see, Pamuk 2000).

Gumushbazar is located in the western-most district of Amasya Province of Turkey, 20 Kilometers from the larger town of Merzifon. The town achieved some prosperity during the 13th and 14th centuries due to the nearby silver mines. The Seljuk's minted coins in the town (Diler, 2009)

The nine silver coins in this research have been selected for analysis are shown in Plate I. They had been kept in private collections. After selecting silver coins and classified by us according to kings name and place of mint it has been engraved, The coins belonged to Seljuk's of Rome [The Seljuk's of Rome are a branch of Iranian Great Seljuk's. This dynasty ruled in Asia Minor in behalf of Great Seljuk's. This branch of Seljuk's in historical text have various name like: Seljuk's of Rome, because Anatolia was in territory of Byzantine, or Seljuk's of Anatolia], two coins belong to Kay-kubad II Ibn Kay-khusraw I, one coin belong to Kay-kavus II Ibn Kay-khusraw II, one coin belong to Kilij Arsalan III and five coins belong to Kay-kavus II, KilijArsalan III and Kay-kubad II period and according the engraving place of mint house by they were classified as the minted in Konya, Sivas and Gumushbazar. The weight of coins varied between 2.39 and 3 gr. and the silver coins were submitted to the PIXE for spectroscopy to elemental composition study.



Map 1: Location of Konya, Sivas and Gumushbazar in Turkey map

MATERIAL AND METHODS

Sample Preparation

We have selected nine silver coins of Roman Seljuk which were in a private collection. Coins have been cleaned by Acetone and distilled water before submitting to the Van de Graff laboratory.

The selection of coin was random due to the absence of coins under study in Iran. Access to other types of coins were difficult due to absence of circulation of Roman Seljuk coins in Iran

Experimental setup

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

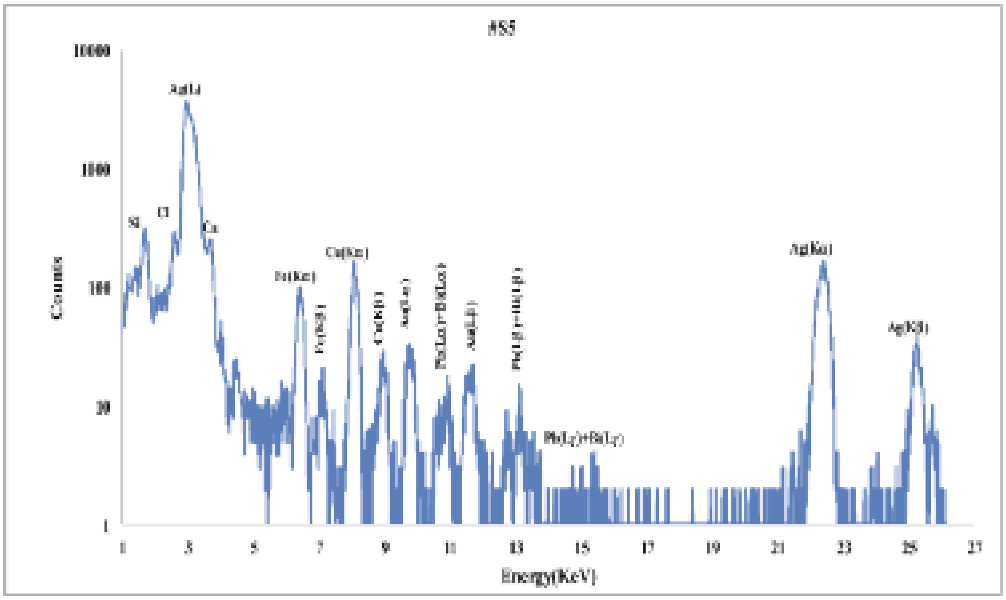


Fig 1: Typical PIXE spectrum of coin No.3

RESULTS AND DISCUSSION

In this study, nine silver coins belonging to Seljuk's of Rome were analyzed by PIXE technique. Ten elements Ag, Au, Pb, Cu, Fe, Cl, Ca, Si, Ti, Bi were determined in the examined coins (Table 1). Average of Ag in coins showed higher amount of Ag is in coins minted in Konya (Fig 2) which indicates a good stability and economic situation at this city. With regard to the Au which is an indicator of silver sources (Kallithrakas-Kontos et al., 2000), Fig. 3 shows that the sources of silver used for coins number 5, 7 and 8 are different from the other coins. As it can be seen in Fig. 3, if we include the measurement errors the ratio of Au/Ag is almost the same for the rest of the coins, but for coins number 5, 7, and 8 the difference becomes a little bit high. Cu was added for hardening and it can be varied for different coins. In Fig. 3, we have defined a classification which can prove this claim. Our results shows Pb in samples, which indicates usage of lead and zinc mines in minting coins (Uzonyi et al., 2000); and less percentage of Pb in some of

Table 1: Percentage concentration (%) of present elements in the analyses coin by PIXE. Remark (0.0): Elements not detected are beyond of detection limit or not found.

Date of mints	King	Weight	Bi	Pb	Au	Ag	Cu	Fe	Ti	Ca	Cl	Si	Sample
1221 AD	Kay-kubad II	2.94	0.00	1.09±0.1	0.72±0.1	92.36±4.6	4.50±0.5	0.00	0.00	0.82±0.1	0.51±0.1	0.00	1
1224 AD	Kay-kubad II	2.89	0.00	1.55±0.2	0.75±0.1	89.36±4.5	6.83±0.7	0.00	0.00	0.89±0.1	0.62±0.1	0.00	2
1251 AD	Three Kings	2.85	0.71±0.1	0.39±0	1.29±0.1	90.25±4.5	1.27±0.1	0.62±0.1	0.00	2.51±0.3	0.90±0.1	2.06±0.2	3
1251 AD	Three Kings	2.50	0.32±0	0.82±0.1	0.89±0.1	93.62±4.7	2.28±0.2	0.00	0.00	1.14±0.1	0.67±0.1	0.26±0.03	4
1251 AD	Three Kings	2.39	1.3±0.1	0.74±0.1	1.59±0,2	91.37±4.5	2.70±0.3	0.07±0.1	0.00	0.92±0.1	0.76±0.1	0.54±0.05	5
1251 AD	Three Kings	3.00	0.00	1.09±0.1	1.06±0,1	88.58±4.4	3.14±0.3	2.32±0.2	0.06±0	1.1±0.1	0.64±0.1	2.01±0.2	6
1251 AD	Three Kings	2.88	0.00	1.09±0.1	0.24±0	93.69±4.7	2.71±0.3	0.03±0.0	0.00	1.01±0.1	0.62±0.1	0.61±0.06	7
1201 AD	KilijArsalanIII	2.85	0.00	0.29±0	0.34±0	96.85±4.8	1.94±0.2	0.00	0.00	0.58±0.1	0.00	0.00	8
1217 AD	Kay-kavusII	2.80	0.00	0.35±0	1.09±0.1	96.00±4.8	1.38±0.1	0.06±0.0	0.00	0.40±0	0.72±0.1	0.24±0.03	9

coins can indicates good silver refining process (Tripathy et al, 2010). Our results (Table 1) show some amount of Fe in coins which presence of Fe is attributed to external pollution with dust incrusted at the surface of the coin (Flament and Marchetti, 2004).

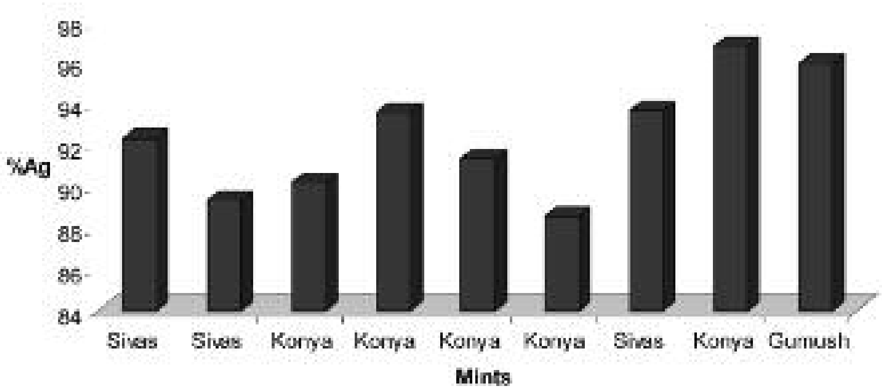


Fig.2 Mints location and silver percentage in the analyzed coins.

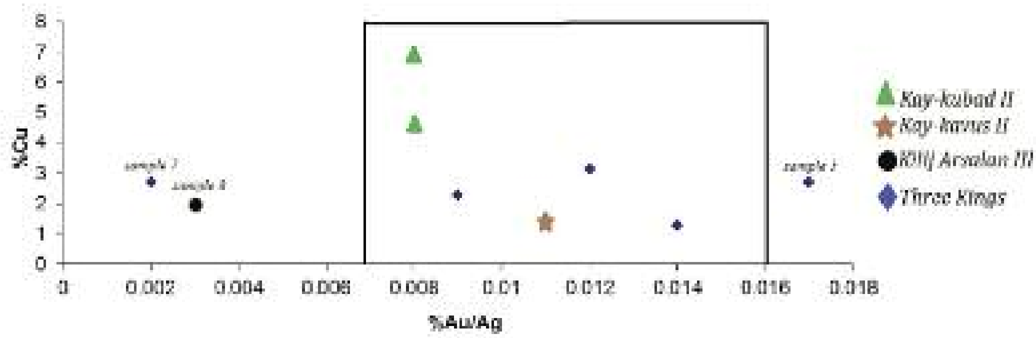


Fig.3 The percentage of Au/Ag and Cu in the analyzed coins by PIXE for various Kings and for the samples 5, 7, 8.

High levels of Fe in coin No. 6 indicate the extraction of silver from lead and zinc associated with iron (Kantarelou et al., 2011). Copper could be present as a result of deliberate addition (concentrations higher than 2-3%), either in small quantities for hardening purposes after cupellation, or in larger quantities due to monetary policy (Kantarelou et al, 2011), High concentration of Cu in coins indicates that it is deliberately added to silver for hardening purposes or economic reasons (Tripathy et al, 2010) (Fig 3). High level of lead and high level Au are observable in coin No. 6 which was assumed as due to the remelting of silver sources. Presence of Bi may indicate different sources (Kallithrakas-Kontos et al., 2000) which are observable in coins 3, 4, 5, and the absence of bismuth implies possibly sources form non-Bismuth ores. The variations of percentages of gold in silver are indicating that silver has been extracted from different mines.

CONCLUSION

In the beginning of the period of the reign of Roman Seljuk and after their looting of Byzantine realm, there occurred re-melting of silver and gold coins and this is possibly observable in one of these silver coins which in comparison to the other coins with high amount of gold and lead. Concentration of Au and Pb indicates the silver source used in coinage. High concentration of Cu in coins indicates deliberate addition to show monetary policy or economic necessity. As a result, lead could be an indicator of the technological level of purifying processes; less percentage of lead indicates better technology of extraction of silver from lead and zinc mines. High levels of Fe in coins indicates either use of silver ores associated with Fe or due to contamination.

Concentration of Ag in the silver coins is the sign of coins of Konya because the city was the capital of Roman Seljuk. Lead is considered as the technical key in the mint houses: when lead levels are similar it indicates that silver was extracted from ore mines nearly with the same technique. Absence of Bi in some coins and its presence in other samples may be an indication of different sources; the same applies for gold concentration in coins and these are observable in Konya mint house.

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