PRELIMINARY ARCHAEOMETRIC STUDIES AND RESULTS OF FAKE DENARS FROM FRIESACH FOUND IN THE INHERITANCE OF A COMMUNITY IN THE ÁRPÁD-ERA DEALING WITH MONEY EXCHANGE•

EGY PÉNZVÁLTÁSSAL FOGLALKOZÓ ÁRPÁD-KORI KÖZÖSSÉG HAGYATÉKÁBAN (OROSHÁZA, BÓNUM, FALUHELY) FELLELT HAMIS FRIESACHI DENÁROK ELŐZETES ARCHAEOMETRIAI VIZSGÁLATÁNAK EREDMÉNYEI

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Abstract

One has to know the geographical environment determining the possibilities of people living in a particular geographical region, in order to attain knowledge on their everyday life. Orosháza is a very important city in this point of view and it had an outstanding road-network. In the surrounding of this city a large number of metal artefacts was discovered in a Muslim settlement next to Orosháza dating back to the 12-13th century. The majority of these artefacts are coins, including few dozens of denars coming from Friesach. According to archaeological assumptions most of them are counterfeit. These fake coins are very exciting for us because they refer to the period and the place of the money exchange and may shed light to methods and variegation of forgery in that time. Due to this we aimed to accomplish archaeometric studies on these coins. The first method was non-destructive chemical analysis with handheld and portable X-ray fluorescence spectroscopy (pXRF). The chemical composition of 25 coins was determined and the first results show that most of the coins are bronzes (tin-copper alloy) with 1-4 wt% lead content, yet, there was one coin with significantly high lead content (14 wt%). In three coins high level of silver content was measured (86 - 97 wt%) but according to the concentration of some trace metals (Cu, Bi, Pb, Au), which can indicate different provenance of the silver material, these three coins differ from each other. Among these 25 pieces of coins, mercury was detected on the surface of 14 indicating amalgam silvering which could be a method of counterfeiting. Besides pXRF which is fundamentally a surface analytical technique, further examinations are planned to get more precise and suitable information.

Kivonat

Ahhoz, hogy egyes földrajzi régiókban élő emberi közösségek életét megismerhessük, meg kell ismernünk magát a földrajzi környezetet, ami nagyban meghatározza a benne élők lehetőségeit. Orosháza tekintetében, annak kiváló úthálózatát kell elsősorban kiemelnünk, valamint azt, hogy a város környékén igen nagy számban kerültek elő fémleletek egy 12-13. századi, muszlim kereskedők lakta telepről.Az itt talált fémleletek többsége pénzérme, melyek között megtalálható pár tucat friesachi dénár is, amik többségüken korabeli hamisítványok a régészeti feltételezések szerint. Ezek a hamis érmék a legizgalmasabbak, melyek a korszakolás mellett kijelölik a pénzváltás helyét is számunkra, és rávilágítanak a korabeli pénzhamisítás sokszínűségére is. Hogy közelebb jussunk ehhez a kérdéskörhöz, archeometriai vizsgálatokat terveztünk a pénzérméken, amely során elvégeztük az érmék roncsolásmentes kémiai elemzését kézi hordozható röntgenfluoreszcens spektrométerrel (pXRF). Meghatároztuk a 25 darab pénzérme kémiai összetételét, amely azt mutatta, hogy a legtöbb érme anyaga bronz (ón-réz ötvözet) 1-4 tömeg % ólomtartalommal. Ezek közül volt egy pénzérme jellemzően magas (14 tömeg %) ólomtartalommal. Három érme esetében mutattunk ki kiemelkedően magas ezüsttartalmat (86 – 97 tömeg %), valamint eltérő nyomelem összetételt (Cu, Bi, Pb, Au), ami az ezüst alapanyag eltérő provenienciájára, így a három ezüst érme különböző eredetére utalhat. A 25 darab vizsgált pénzérméből 14 esetben mutattunk ki higanyt

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a felületeken, ami a tűzi ezüstözésre utal, amely technika a pénzhamisítás egyik lehetséges módszere. A pXRF technika mellett, ami alapvetően felületanalitikai módszer, egyéb mérési módszereket is tervezünk a még pontosabb és megbízhatóbb információk szerzése céljából.

KEYWORDS: FRIESACH DENARS, FORGERY, SILVERING, PXRF, MULTIVARIATE DATA ANALYSIS

KULCSSZAVAK: FRIESACHI DÉNÁROK, HAMISÍTÁS, EZÜSTÖZÉS, PXRF, TÖBBVÁLTOZÓS ADATELEMZÉS

Introduction, archaeological background

Orosháza played an important role in merchantry among Hungarian cities in the 12-13th century owing to its excellent road-network (Langó & Rózsa 2012; Rózsa & Tugya 2012; Rózsa 2017). At the bend of the ancient Maros river an earth fort was formed in the Late Bronze Age and in the 20th century there was an army base at the border which was located at the ancient salt trading route explaining the presence of Muslim money-changers at that time (Rózsa & Tóth 2018). The heritage of this community is well-known for archaeologists from excavations and intensive metal detecting works in the area. During this activity several weights made of lead and parts of balances and many coins from Friesach, called Friesach denars, were found and this latter has special information for us due to their importance in dating. The most exciting denars artefacts are the counterfeits or fake Friesach denars showing us location of the money exchange and various methods of contemporary forgery. In the first half of the 12th century the Salzburgian archbishop founded a mint in Friesach, a city located in Carinthia, from the name of denars is originated. There are other coins which were produced in other mints of the archbishop, dukes and lords from Carinthia and South Austria are called Friesach denars as well. Therefore this kind of denars was produced mainly in the area of Austria and Slovenia (Baumgartner 1949). By the end of the 12th century the Hungarian denar became weaker comparing denars from Köln, Friesach and Regensburg due to inflation (Hóman 1916) and owing to rising of the economy and prosperity of trading connections outlandish currency played more significant role in the cash flow of the Kingdom of Hungary resulting the dominance of Friesach-type money at the turn of 12-13th century. This kind of denars form the biggest part of treasure-trove and coin artefacts from the first half of the 13th century in Hungary (Tóth 2007). Among these coins there are no any faked ones at all excepting denars found in village of Bónum located next to Orosháza and these fake denars were strained off presumably by the Muslim money-changers working in this village (Rózsa 2018). By studying and examining these denars we may get more complete knowledge about counterfeit and money circulation of the Árpád-era and the history of Bónum village as well.

Materials and methods

Handheld, portable X-ray fluorescence analysis (pXRF)

The non-destructive chemical analysis of the coins was performed using a Thermo Scientific Niton Xl3t GOLDD+ instrument with 50 kV X-ray tube with silver target (Ag anode) and geometrically optimized large area drift detector which is able to detect the elements from Mg to U. This spectrometer has company-preset calibrations for given matrices and in our case "General Metals" and "Precious Metals" were used. For all analysis two energy filters for radiation were applied including 'Main', and 'High' filter. The third one ('Light' filter) was not used in order to get complete and real composition of the studied alloys eliminating non-relevant elements (Si, Al, Ti) coming from surface contaminations (soil or dust layer). Measuring time was 60 sec in all cases using 30-30 sec for each filter. Measuring spot size (irradiation area on the object surface) was 8 mm in diameter. Before measuring the surface of the coins was cleaned to remove contaminations (dust, soil, etc.) to measure real material of the artefacts. Standardless fundamental parameters method with Compton-normalization is used by the pXRF for quantitative analysis and results were also checked by evaluating the corresponding spectra with NDT software (Niton Data Transfer, version 8.0.0). Mathematical and statistical data processing was done with Excel and Statistica 12 software.

Results and discussion

The chemical composition of the coins (**Fig. 1a, Fig. 1b**) is reported in **Table 1**. The concentration values are given with taking into account the average uncertainty of pXRF method (5-10 %). Most of the analysed coins were made of bronze with varying Cu-Sn ratio, according to the pXRF results. In case of two coins the Sn content is higher than the Cu content. In all cases a slight concentration level of Zn was measured (0.15 – 2.5 wt%) except two coins with very high copper content (97 wt%) close to pure copper. Every coin has a few percent Pb (0.1 – 7.0 wt%) content, except one coin where this value is 14 wt%. Among the 25 analysed coins there are three with significantly high Ag content (86 – 98 wt%) so these can be considered as silver coins or silver denars (23, 24, 25).

Table 1.: Results of the pXRF measurements of the coins expressed in wt%. In the column of Hg, the ++ indicates the presence of mercury. The exact value of mercury concentration is not indicated because quantitative evaluation of this element is not included in the calibration package of the pXRF.

1. táblázat: A pénzérmék kémiai összetétele tömeg %-ban kifejezve a pXRF mérések alapján. A Hg oszlopban lévő ++ jelek mutatják a higany jelenlétét az adott érme felületén. A számszerinti higanykoncentráció nincs feltüntetve, mert a Hg elem mennyiségi értékelése nincs benne a spektrométer gyárilag beépített kalibrációjában.

Sample number	Cu	Sn	Zn	Sb	Pb	Bi	Ag	Au	Hg
1	93.5	3.96	0.15	0.12	0.92	0.08	0.42	0.14	++
2	87.2	7.10	0.66	1.37	1.89	0.02	< 0.02	< 0.002	
3	97.3	1.91	< 0.02	0.21	0.07	< 0.01	< 0.02	< 0.002	
4	85.4	9.61	0.30	0.03	3.49	0.07	0.36	0.24	++
5	44.0	44.1	2.49	0.05	6.90	0.04	< 0.02	< 0.002	
6	35.4	60.3	0.30	0.11	0.98	< 0.01	< 0.02	0.04	++
7	67.2	26.4	0.29	< 0.05	2.73	0.08	0.33	< 0.002	
8	54.2	38.5	0.83	0.05	3.88	0.15	0.76	0.32	++
9	91.8	3.87	0.12	0.05	2.66	0.23	0.45	0.03	
10	90.5	4.55	0.17	0.08	2.77	0.26	0.39	< 0.002	++
11	95.0	1.56	0.15	0.11	1.37	0.04	0.38	0.16	++
12	81.3	14.3	1.03	0.38	2.27	0.08	< 0.02	< 0.002	
13	52.5	32.2	0.17	< 0.05	13.6	0.07	0.53	< 0.002	++
14	65.7	25.5	0.55	< 0.05	4.53	0.11	0.77	0.25	++
15	86.1	10.3	0.27	0.03	2.41	0.06	0.26	0.22	++
16	78.0	19.9	0.39	0.39	0.67	0.01	< 0.02	< 0.002	
17	17.9	75.3	0.24	0.06	4.04	0.10	< 0.02	< 0.002	++
18	94.1	2.86	0.12	0.35	1.19	0.02	0.32	0.06	++
19	65.1	30.8	0.52	1.08	0.51	< 0.01	0.22	< 0.002	++
20	70.4	26.0	0.25	< 0.05	1.64	0.04	0.27	0.27	++
21	81.7	14.2	0.30	0.85	0.45	< 0.01	< 0.02	< 0.002	
22	96.7	0.94	< 0.02	0.10	0.31	< 0.01	0.36	0.10	++
23	12.7	< 0.3	< 0.02	0.24	1.30	0.27	85.8	< 0.002	
24	1.46	< 0.3	< 0.02	< 0.05	0.19	0.46	97.6	0.05	
25	3.17	< 0.3	< 0.02	< 0.05	0.56	0.03	96.3	< 0.002	

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Fig. 1a-b: Photo of the front and back side of studied coins

1a-b ábra: A vizsgált pénzérmék elő- és hátlapjaink fotói

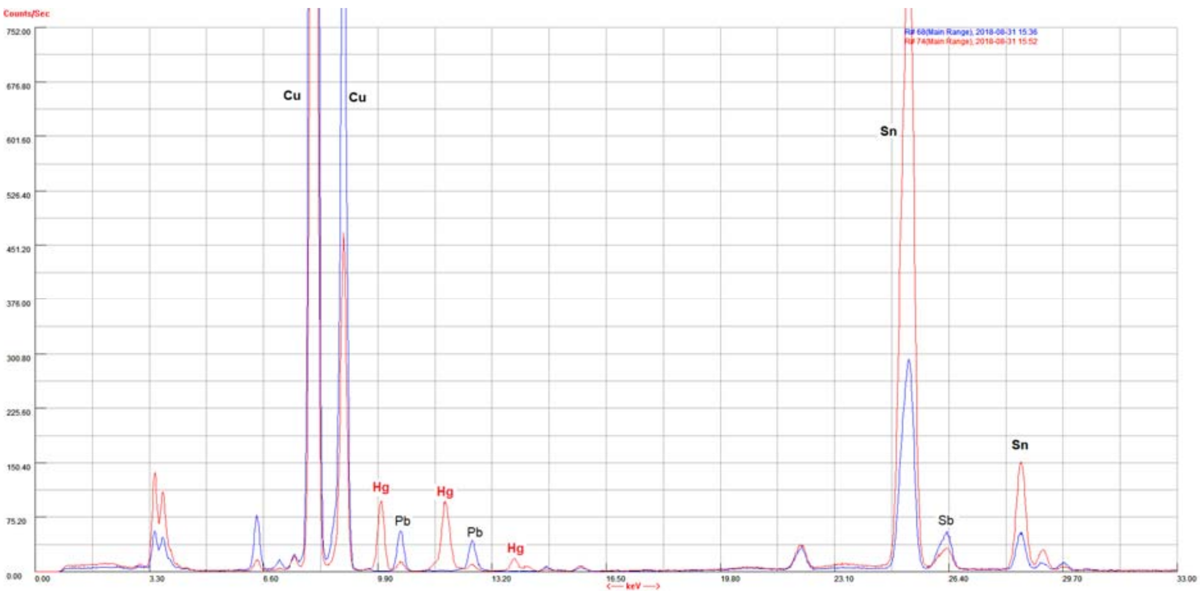

Fig. 2.: A detailed and magnified XRF spectra of an amalgam silvered (red spectrum) and a non-silvered (blue spectrum) coin surface.

2. ábra: Egy tűzi ezüstözött és egy nem ezüstözött pénzérméről felvett XRF spektrum nagyított részlete.

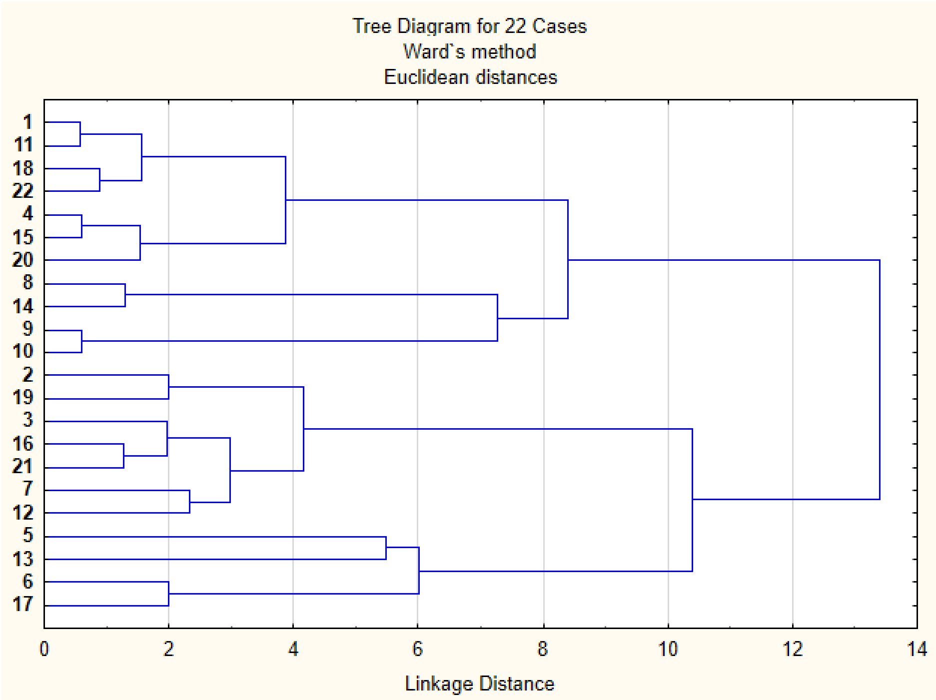

Fig. 3.: Diagram of the cluster analysis (dendrogram) of 22 coins based on their chemical composition measured with pXRF.

3. ábra: A 22 pénzérme pXRF módszerrel mért kémiai összetétele alapján ábrázolt dendrogram (klaszterelemzés).

This result is in good accordance with an earlier study about coins from the time of Tatar Invasion (Nagy 2013). In the case of 14 coins Hg content can be detected according to the XRF spectra as it can be seen in **Fig. 2.** Exact values of Hg concentrations are missing at the moment due to the limits of the factory settings of the XRF device. The presence of mercury on the coin surfaces may indicate a method of forgery where the silvering process of the bronze coin was done with amalgam silvering, producing a coin that looks like a real silver one. The three silver denars do not contain mercury.

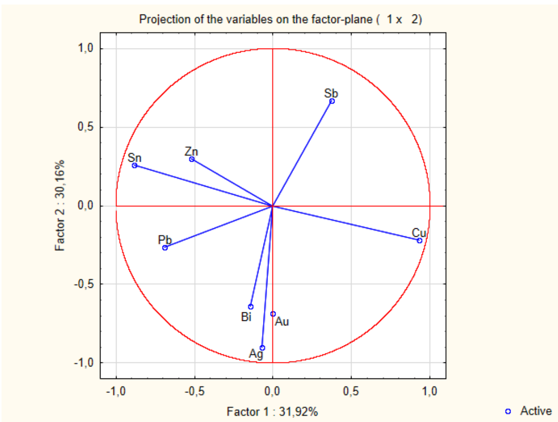

Fig. 4.: Diagram of the principal component analysis of 22 coins based on their chemical composition measured with pXRF.

4. ábra: A 22 pénzérme pXRF módszerrel mért kémiai összetétele alapján számolt főkomponens elemzés ábrája

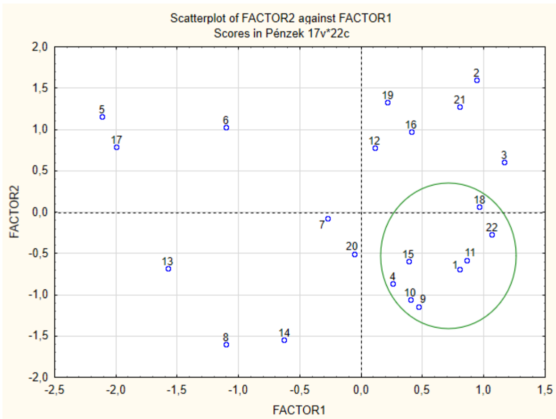

Fig. 5.: Diagram of the factor analysis (dendrogram) of 22 coins based on their chemical composition measured with pXRF.8 coins (number 11, 18, 22, 1, 15, 4, 9 and 10) belong to a well-defined group (green circle) indicating the same workshop of producing them.

5. ábra: A 22 pénzérme pXRF módszerrel mért kémiai összetétele alapján számolt faktorelemzés ábrája. 8 pénzérme (mintaszám szerint: 11, 18, 22, 1, 15, 4, 9 és 10) egy jól meghatározott csoportot alkot (zöld körben jelölve), ami arra utal, hogy ezek azonos műhelyben készülhettek.

We conducted multivariate data analysis on the pXRF results in order to find tendencies, groups and connections between the analysed denars based on their chemical composition. The three silver coins are not included in this statistical evaluation, because they form a very differing group separated from the other 22 pieces of coins due to their very high silver content.

Results of cluster, principal component and factor analysis of the 22 pieces of denars can be seen in **Fig. 3., 4.** and **5**. In **Fig. 4.** (PCA) the chemical elements measured with pXRF can be seen and the directions in this new coordinate system of Factor 1 and 2. With comparison of PCA and FA figure we can clearly see which elements cause separation of the samples into groups during statistical evaluations. Similarly cluster analysis (CA) also gives useful information about similarity and groups of the analyzed samples but this method itself without PCA or FA is not reliable enough. In our case there is an important group of eight pieces of coins (1, 11, 18, 22, 4, 15, 10, 9) according to the FA analysis (**Fig. 5.**, in the green circle) and four of them form a subgroup (1, 11, 18, 22) which can be also seen in the CA figure (**Fig. 3.**) having relatively high Cu content (> 93 wt%) and coins number 11, 18 and 22 belong to the same type of blank according to archaeological studies.

Conclusions

Most of the analysed (25 pieces) denars are made of bronze with various Cu/Sn ratio. More than half of the coins have mercury content which may indicate amalgam silvering method of forgery. During the first macroscopic examination it could be stated that there is a close connection between three coins (11, 18, 22) historically and it was supported by this preliminary pXRF measurements. This group of 3 denars was completed by further 5 pieces of coins with help of multivariate data analysis methods. These denars are supposed to have been produced in the same workshop and they imitate three types of real denars which were minted between 1170-1200, 1181-1202 and 1200-1246 suggesting that the workshop, where the counterfeits were produced, operated in the first or second decade of the 13th century (Koch 1994). The relatively large number of coins originating from the same place may indicate an adjacent counterfeiter workshop.

These preliminary results and work will be continued and it is planned to accomplish other type of examinations and methods such as SEM-EDX, ICP-AES, ICP-MS to make more precise measurements and get more information and it is also planned to increase the number of analysed coins extending our dataset to do further statistical evaluations.

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