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Investigation of Numismatic Material from the Juchid State (the Golden Horde) of the 13th century (based on the materials of Burundukovsky hoard, Tatarstan, Russia)

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***Abstract* - This work is the result of a investigation of silver-containing numismatic material discovered in the territory of Burunduki village located in the Tatarstan Republic (Russia). The coins were minted in the 13th century in Bolgar during the rule of the Juchid dynasty (the Golden Horde). X-ray fluorescence analysis of transverse fractures was selected as a research method in order to obtain an adequate pattern of chemical element distribution across the structural layers of coin material. The results of this study demonstrated that fracture-base mapping corresponds to physical processes occurring in the course of pressure processing. As a result, local material can clearly be classified into two groups in terms of chemical composition and manufacturing technique.**
***Keywords* – archaeological silver coins, Golden Horde, Volga Bolgaria, 13th century, chemical composition, embossing technology, X-ray fluorescence analysis.**

I. INTRODUCTION

Hundreds of thousands of silver coins belonging to state formations of the Juchid dynasty (the Golden Horde) are known to the scientific world of Oriental numismatics. Several monetary reforms were performed in each of these states, which were revealed on the basis of observations over the decoration and weight characteristics of the coins. However, the attribution and coin weighing system of these reforms have not yet been completely uncovered. In the Middle Ages a currency unit was determined as a quantity of precious metal accepted in this state, area and time period as a measure of prices. Therefore, the study of weight characteristics of silver coins themselves is not sufficient for the determination of currency unit variations in medieval Oriental countries. It is required to carry out a study of the chemical composition and structure of a coin samples manufactured at mints located in various towns and states during different period of their existence.

An active military campaign against the towns of Volga Bolgaria initiated by the Golden Horde in the early 13th century resulted in an active migration of the local population to the relatively safe areas of the Pre-Kama and Pre-Volga regions. This led to an expansion of the trade and economic area of Volga Bolgaria and the emergene of minor к trade and craft quarters, e.g. Lukovskoye settlement.

Of great scientific interest is the fact that a wide variety of minted coins appeared in the 13th-15th centuries, which cannot always be clearly classified as belonging to a certain local ruler. During that period coins began to be minted directly in the area controller by a local governor.

A hoard was discovered in 1987 near Burunduki village of the Tatarstan Republic. The hoard was deposited not later than the 1260s [1]. A total of 906 hoards have been found, including a single coin0shaped silver pendant. All the coins were minted at the mint located in the Bolgar - the capital of Volga Bolgaria. For a long period of time the hoard was only studied using classical techniques of numismatics: attribution in accordance with the stamp, metrology and morphology of the surface. However, these techniques do not provide a clear notion of the chemical composition and manufacturing technique of the coins.

Presently, several techniques are available, which allow to study the chemical composition and structure of materials. A classic technique of studying the chemical composition of coins is the emission-spectral method which provides the most accurate determination of the impurity composition of materials. However, one cannot establish a layer-by-layer composition using this technique, and moreover, the sample is destroyed in the process, because a significant amount of material is required for analysis.

Experience in the application of scanning electron microscopy [2] has yielded good results when the inner structure of the coins was studied, and it allows to carry out layer-by-layer research of the chemical composition, but the accuracy of impurity analysis provided by this technique is not very high. It is also a destructive method, which is attributed to the small valume of the working chamber and the fact that a newly made fracture is required in order to obtain an adequate pattern.

The use of double-pulse laser atomic-emission spectroscopy for layer-by-layer determination of chemical composition described in work [3] also results in destruction of coins. The limitation of this technique is the unknown location of a coin's structural layers which results in random determination of the layers. Apart from that, inevitable evaporation of pit walls blurs the pattern of each subsequent layer.

X-ray fluorescence does not allow to carry out layer-by-layer studies of samples, or determine the variation of element concentration at different depths [4-6]. However, this techniaue is non-destructive, and during the development of a method for the research of transverse fractures of a sample can provide a rather accurate chemical element distribution pattern across a coin's structural layers.

Various cleaning methods and special preparation of coins as described in works [7,8] can result in blurring of the pattern of element distribution inside a coin. It is clearly evidenced in work [2] where a "blurred" transverse fracture of a coin caused a several-fold increase of silver content in the centre of the coin.

II. MATERIALS AND METHODS

The proposed work is dedicated to a study of 7 silver monetary artefacts from Burundukovsky hoard. The series of samples comprises 2 coins emitted by An-Nisir, 2 coins emitted by Mongke Khan, and 2 coins minted by Ariq Boke (ref. Table 1). The coin-shaped silver coin discovered in the same hoard was used as a reference standard (ref. Table 1).

The technique of silver-containing material sampling for coin research providing adequate results is described in paper [2]. Due to the fact that this technique has provided correlating results obtained using various research techniques (optical emission analysis, scanning electron microscopy, X-ray fluorescence analysis), XRFA (X-ray fluorescence analysis) was used in the paper as the research technique.

The analysis was carried out using a Tornado X-ray phase analysis spectrometer manufactured by Bruker. An M4 Tornado polycapillar micro-XRF spectrometer (Bruker, Germany) allows to determine the elemental composition of solid, powder and liquid samples within the range of Na to U in a point with diameter 25 micron in air or vacuum. This instrument allows to plot a pattern of elements' distribution across the surface of a sample dimensioned up to 33x17 cm, and 3D distributions of elements within a sample.

Table 1. Attribution of coin material.

	Attribution
1	Nasir al-Din-Allah, Bolgar, with no indication of year. Head (a): a three-line phrase in a dotted band reads "An-Nasir li // Din Allah ruler // of the righteous"; Tail (p): a three-line phrase in a dotted band reads: "Dinar // minted in Bu//algar".
2	A coin emited by an-Masir-lid-dinni-Llah, Bolgar mint, first half of the 13th century. a: the band is not visible, a three-line phrase reads: "An-Nasir ad//Din Allah the ruler//of the righteous" with a hexagonal star above the upper line; p: a fragment of a dotted band, and a three-line phrase: the three-line phrase reads: "Dinar//minted by Bu//algar".
3	A coin emitted by Mongke Khan (1251-1259) at Bolgar mint; a: the band is not visible, a three-line legend reads: "Mengu ka(an)//the Supreme", No tamga can be seen between the lines; p: the cartouche is not visible, a two-line phrase reads: "Minted/in Bolgar", and no tamga can be seen between the lines.
4	A coin emitted by Mongke Khan (1251-1259) at Bolgar mint; a: the band cannot be seen, and the single-line legend reads: ".... //the Supreme", the bottom portion of a tamga is visible between the lines; p: the cartouche is not visible, the following single-line phrase has remained: "...//of Bolgar", and only the crosspiece of a tamga has preserved between the lines.
5	A coin emitted by Ariq Boke Khan (1260-1264) at Bolgar mint, a: a two-line phrase reads: "Ariq Boke Kha//(a)n the Supreme." A vignette is located underneath the phrase; p: there is a two-line phrase which reads "Minted in//Bolgar" in a similar cartouche
6	A coin emitted by Ariq Boke Khan (1260-1264) at Bolgar mint, a: there is a two-line phrase inscribed in a dotted circle which reads: "Ariq Boke Kha//(a)n the Supreme." A vignette is located underneath the phrase; p: there is a two-line phrase which reads "Minted in//Bolgar" in a similar cartouche
7	Coin-shaped pendant with a hole emitted by Mongke Khan (1251-1259) at Bolgar mint

III. RESULTS AND DISCUSSION

The chemical composition, characteristic features and morphology of the coins are specified below.

Coin No.1 has a round shape and is made of high-grade silver: Ag – 96.03%, Cu – 2.92%, Pb – 0.37%, Au – 0.6%. The coin features a three-layer structure with very thin outer layers (20-30 µm). The concentration of copper in the outer layer is significantly less than that in the inner layer. Colour visualization demonstrates the absence of the lead component in the outer layers, and the distribution of this element across the surface of the inner layer is homogeneous. Correlation of copper and gold is clearly visible, which indicates a certain source of raw material. The inner layer features traces of cold-work strengthening, which signifies the use of high load for coin manufacturing.

The circular shape of the coin indicates that the blank used for its minting had an identical shape. S-shaped grooves have preserved on the edge of the coin, which are characteristic of free pressing between the two parallel surfaces.

The second coin (No.2) has a round shape and is made of high-grade silver as well: Ag – 92.09%, Cu – 3.06%, Pb – 0.61%, Au – 0.83%. Figure 1 features an image obtained by elemental mapping.

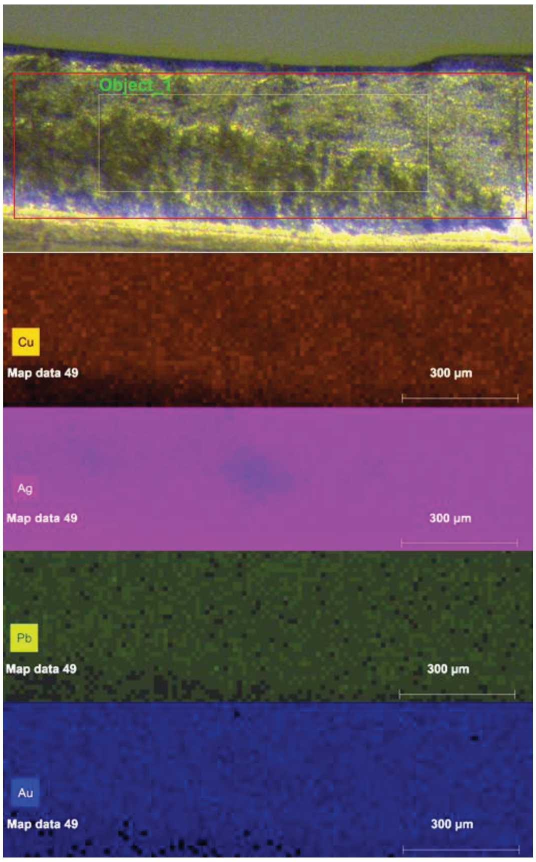

Fig. 1. Distribution patterns of general chemical elements in coin No.2

The distribution of elements across the area of the fracture is homogeneous except for a thin surface layer (bottom left corner) which has a lower impurity content than the inner portion of the coin. No evident correlation between elements is observed. Likewise coin No.1, the inner portion of the coin contains a heavily deformed layer with recrystallization of the surface.

The minting technique of this coin corresponds to that of coin No.1.

Coin No.3 has an elongated oval shape and is made of high-grade silver: Ag – 93.88%, Cu – 4.99%, Pb – 0.52%, Au – 0.54%. The coin is very thin (250-300 µm) and has a prominent laminar structure, which can signify stretching of the silver base of coin material. This artefact was presumably crafted using a stretched silver wire. This is confirmed by its elongated oval shape with a characteristic thickening and a mark left by cutting of the coin from a continuous elongated blank. The tin outer layer contains no lead, which can indicate that the coin was coated with a higher-grade silver or heavy etching of the coin. Non-homogeneous distribution of lead and gold across the inner layer can signify insufficient melting temperature during manufacturing of the blank, as a result of which these elements did not dissolve in the alloy matrix.

Mongke Khan coin No.4 has an oval shape and is also characterized by a high grade of silver: Ag – 93.69%, Cu – 4.98%, Pb – 0.52%, Au – 0.54%. The plasticity of coin material did not allow to obtain a brittle fracture, therefore the element distribution pattern failed to uncover any characteristic features in terms of the structure and distribution of chemical elements.

The coin does not have an oval shape characteristic of coin No.3. However, traces of cutting have preserved at one of its sides.

Coin No.5 has an oval shape and is made of high-grade silver: Ag – 91.62%, Cu – 4.85%, Pb – 0.77%, Au – 0.45%. The distribution of elements across the mapping area is homogeneous.

The outer shape of the coin demonstrates that it was crafted from a plate. Corners in the form of mold flash corresponding to rectangle vertices have preserved on coin edge. No traces of cutting have preserved. It can be assumed that the coin was minted from a flattened wire.

Three-layer coin No.6 features an oval shape and a high silver content: Ag – 93.6%, Cu – 5.18%, Pb – 0.66%, Au – 0.55%. Distribution of elements across the scanning area is homogeneous (Figure 2). The inner layer contains inclusions in the form of lead-and-copper conglomerates. Similarly to coin No.1, gold correlates with copper, excluding the inner layers in which higher Au concentrations are observed (Figure 2).

The coin has on oval shape similarly to coin No.5, and a faint trace of cutting has preserved on one of the sides. A wire-shaped blank was presumably used during minting.

Coin-shaped pendant No.7 features the following chemical composition: Ag – 94.9%, Cu – 3.35%, Pb – 0.77%, Au – 0.32%.

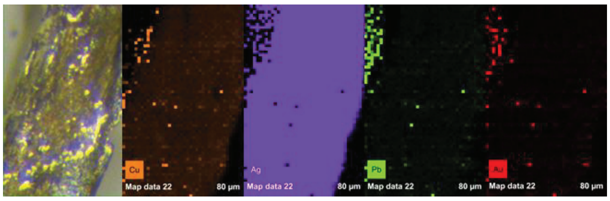

Fig. 2. Distribution patterns of general chemical elements in coin No.6

The pendant has an oval shape, single-sided stamping and a punched hole. No traces of cutting are observed, and the blank presumably had a round shape in the longitudinal cross-section.

The artefact has a three-layer structure similar to that of coin No.6. Unlike the first coins No.1 and No.2 copper and gold in the pendant feature a reverse correlation, and the distribution of silver matches the distribution of gold on colour maps (Figure 3). The concentration of these elements in higher in outer layers. This circumstance indicates a different source of silver compared to the first coins.

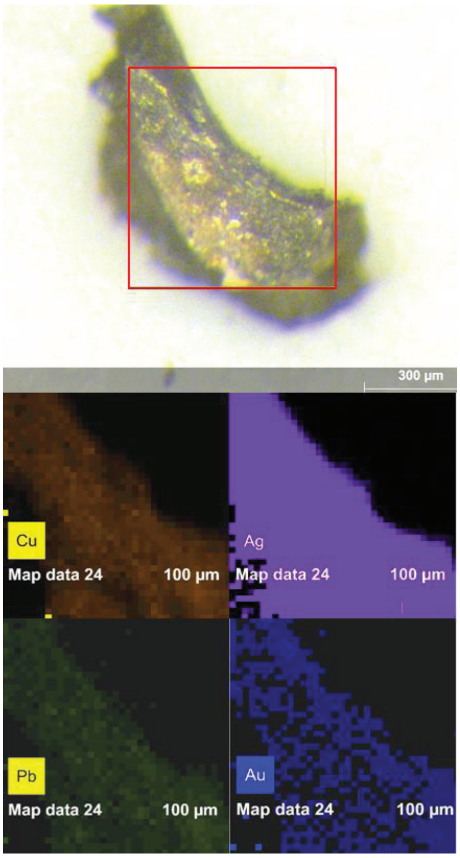

Fig. 3. Distribution maps of general chemical elements in coin-shaped pendant No.7

IV. CONCLUSION

The research of numismatic material by means of X-ray phase analysis has allowed to discover a series of patterns related to the characteristic features of the manufacturing procedure:

- all coins and the pendant are composed of high-grade silver;
- general admixtures in the silver are copper, lead and gold;
- raw material for coins emitted by An-Nasir and the coin-shaped pendant is slightly different from other coins in terms of copper content;
- all blanks for the coining die were made using pressure processing;
- blanks for coins emitted by An-Nasir and the coin-shaped pendant had an oval shape;
- blanks for coins emitted by Mongke Khan and Ariq Boke had the shape of a wire;
- coins emitted by An-Nasir were subjected to high uniform load; the possible techniques used for their manufacture were pressing between two surfaces and die moulding, or pressing with simultaneous application of a pattern on the coin surface;
- coins emitted by Mongke Khan and Ariq Boke were minted in a single stage by means of a swift hammer blow with simultaneous application of a pattern on the coin.

Thus, this research allowed to reveal the following 2 coin manufacturing techniques: coin manufacturing by forging from wire and pressing from round blanks.

In general, coin minting in the 13th century differed significantly from the technologies used in the 9th-11th centuries. [2,9]. First of all, no cast coins have been discovered. Structural changes in the form of cold-work strengthening inside the coins indicates a change of tools aimed at obtaining a denser packing on coin bodies. Variously shaped blanks appeared, and continuous cylindrical blanks (wire) began to be used along with plate-shaped materials.

The performed research demonstrated that several coins have a three-layer structure, However, the image resolution does not allow to draw certain conclusions, including the issue of the etching technique used for the processing of coin surface. Supplementary research is currently conducted with the use of the scanning electron microscopy technique.

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