

Studies of coins of medieval Volga Bulgaria by neutron diffraction and tomography

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Studies of the physicochemical properties of ancient coins are one of the important areas in the non-destructive testing of cultural heritage sites. Numismatic material stores valuable information about the trade, economic and social development of ancient civilizations and states. It is known that the study of the chemical composition and internal structure of coins can provide important information about the deposits of silver or gold ore, from which coins are made, conformity with a specific historical period or features of minting, and identification of fakes.

Compared with the methods of X-ray fluorescence analysis, electron microscopy and metallography used in archaeological scientific communities, neutron research methods have high penetrating power into the thickness of metal objects. Since, due to the peculiarities of casting and chasing medieval silver coins, they are characterized by an uneven distribution of chemical components throughout the volume, the use of methods of neutron diffraction, radiography and tomography is justified.

Two coins from the territory of the Volga Bulgaria were selected as objects of research: the Samanid multidirham, dating back to the 10th century, and the dirham of Emir Bulat-Timur (late 14th century), referring to the two most active periods of development of commodity-money relations in the region and the maximum distribution in trade metal coin operations. The study of the crystal structure and phase composition of the coins was carried out using the neutron diffraction method on a specialized diffractometer for the study of micro samples DN-6 at a high-flux IBR-2 reactor. Analysis of diffraction data was performed by the Rietveld method using the FullProf program. The spatial distribution of chemical elements in coins was studied by neutron radiography and tomography at a specialized experimental station on the 14th channel of the high-flux IBR-2 reactor. Due to the varying degree of attenuation of the intensity of the neutron beam when passing through components of different chemical composition, it is possible to obtain information on the distribution of phases within the volume of the material under study with a spatial resolution at the micron level.

As a result of the work, it was established that both of the investigated coins consist of a copper-silver alloy. However, the multidirham is characterized by a very high content of copper - on average, about 50% of the total volume of the material of the coin. The spatial distribution of silver and copper in this coin is inhomogeneous, which may be associated with both the characteristics of the original ore and the processes of coin minting. Dirham is almost entirely made of silver. The volume content of copper in this studied coin is quite low - 5.2%. Neutron data indicate a uniform distribution of silver in the material of the coin. This may indicate an increase in the quality of the source metal and changes in technology.

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