STUDY OF ANTIQUE AND MEDIEVAL COINS BY NON-DESTRUCTIVE METHODS OF NEUTRON TOMOGRAPHY AND DIFFRACTION

B.A. Bakirov[1,2], S.E. Kichanov[1], D.P. Kozlenko[1], I.A. Saprykina[1,3] and B.A. Abdurakhimov[1]

[1]*Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, 141980 Dubna, Russia*
[2]*Kazan (Volga Region) Federal University, 420008 Kazan, Republic of Tatarstan, Russia*
[3]*Institute of Archaeology RAS, 117036 Moscow, Russia*

E-mail: bulatbakirov@jinr.ru

Detailed studies of the physicochemical properties of ancient and medieval coins by modern non-destructive methods are an important task for archeology and sciences related to history. Numismatic material contains valuable information about the trade, economic, technological and social development of ancient states. It is known [1] that the study of the phase and chemical composition, the internal structure of coins can provide important information about the deposits of the ore from which the coins are made, the correspondence to a certain historical period or features of coinage, and the identification of fakes. It should be noted that the experimental data obtained are of great importance for the development of the methodology for the restoration and preservation of not only numismatic, but also other metal archaeological finds [2].
In this work, coins from different territories and historical periods were studied. A set of nine bronze coins from the excavations of the 6th - 3rd BC necropolis on the Taman Peninsula (Krasnodar Territory, Russia) belongs to the Bosporan Kingdom and characterizes the period of active interaction between the Greek and barbarian population of this region. Two silver coins from the territory of Volga Bulgaria (Republic of Tatarstan, Russia), dated to the 10th and 14th centuries AD, correspond to two periods of the maximum distribution of metal coins in the trading operations of this medieval state. Another silver coin dated approximately to the 10th - 13th century AD, minted by the Karakhanid dynasty and found on the territory of modern Uzbekistan, is a clear marker of the so-called "silver crisis". Thus, data studies are of great importance in clarifying some aspects of the development of these ancient states.
To determine the spatial distribution of chemical elements over the volume of coins, neutron radiography and tomography experiments were carried out at a specialized experimental station on the 14th channel of the IBR-2 pulsed high-flux reactor. The studies of the crystal structure and phase composition of the coins were carried out using the neutron diffraction method on a specialized DN-6 diffractometer on the 6th channel of the IBR-2 pulsed high-flux reactor, the analysis of diffraction data was carried out by the Rietveld method.
As a result, for bronze coins, the degree of degradation (the ratio of the volumes of the metal part and patina), the phase composition of the patina, and the tin content in the copper-tin alloy were determined. Additionally, three-dimensional surface models of three coins were successfully restored, which made it possible to correctly identify them. For silver coins, the content of the copper phase and the spatial distribution of the silver and copper phases by the volume of the coins were determined. An increased silver content was found on the surface of two coins, indicating a silvering of the surface.

[1] K.M. Podurets (2021). Modern Methods of Neutron Radiography and Tomography in Studies of the Internal Structure of Objects. Crystallogr. Rep. 66, 254–266.
[2] Th. Rehren (2008). Coins, artefacts and isotopes-archaeometallurgy and Archaeometry. Archaeometry. 50, 232–248.