Using XRF to Determine the Elemental Composition of Dyes in the Painting of Medieval Eastern Faience

V.Yu. Koval[1], A.Yu. Dmitriev [*,2], V.S. Smirnova[2,3], V.V. Lobachev[2]

[1] *Institute of Archeology of the Russian Academy of Sciences, Moscow, Russian Federation*
[2] *Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, Moscow Region, Russian Federation*
[3] *Dubna State University, Dubna, Moscow Region, Russian Federation*
*e-mail: andmitriev@jinr.ru

An X-ray fluorescence analysis (XRF) of the glaze of a glazed medieval eastern ceramics batch was carried out in the NAA group of the IREN research facility of the Frank Laboratory of Neutron Physics, JINR, to determine the marker elements characteristic of various types of raw materials used to manufacture of dyes. 13 samples were obtained from the Institute of Archeology, RAS. Each sample was examined from the glazed sides.

A portable device Bruker Tracer 5i was used for carrying out the X-ray fluorescence analysis. The design features of the device are the ability to install interchangeable collimators and the availability of a built-in video camera. A collimator with a diameter of 3 mm was used for the study. The built-in video camera made it possible to position the sample under investigation relative to the place of the X-ray beam penetration. These features of the device allowed to study the elemental composition of not only the glaze itself, but also to carry out a unique non-destructive researches of various decorative elements with dimensions of more than three millimeters.

Samples were grouped as follows:

a) turquoise transparent glazes without additional decor;
b) white and greenish covered with tin glazes, including luster painting;
c) transparent colored glazes with overglaze colorful and luster decor;
d) colorless glazes of vessels decorated with polychrome underglaze painting.

A comparative analysis was carried out among the groups.

The following conclusions were made based on the results:

1. The turquoise color in the group of turquoise transparent glazes without additional decor is caused by a high content of copper oxide in the mixture. An iridescent view was obtained by iridescence.
2. A large amount of tin, as well as lead and arsenic, which are not dyes but serve as technological additives, is noticed in white glazes muffled with tin. There is an interesting sample in this group. A green and gold painting is applied on this sample. The color of the painting is based on the addition of silver to the mixture.
3. The group of transparent glazes with overglaze colorful and luster decor is represented by samples with multi-colored patterns (blue, brown, green, turquoise). The blue color everywhere in the group is due to the presence of cobalt in the dye, which has a strong coloring effect. Turquoise color, as in group 1, was obtained by adding copper to the dye. Green one is also due to the presence of copper. Brown one is formed by iron. Tin, lead and arsenic are noted in some samples.
4. The study of colorless glazes with underglaze painting was complicated by the fact that X-ray fluorescence analysis is a superficial method. This fact limited the ability to fix the elements under the glaze. However, some elements of the dyes were found: manganese, causing brown color, chrome – green one, copper – turquoise one.

The study can serve as the basis for the formation of a database of archaeological glazed ceramics.