# Classification of Mortars from the St. George Cathedral of the Yuryev Monastery (Veliky Novgorod, Russia) Based on Neutron Activation Analysis Data at the IREN Facility (JINR, Russia) and the WWR-K Reactor (INP, Kazakhstan)

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One of the important components of architectural monuments are mortars, which were used as the main binding material in creating of stone or brick masonry. Over time, the compositions of mortars have changed significantly. This fact can serve as a basis for mortar classification.

The subject of this study is the mortars from the St. George Cathedral of the Yuryev Monastery. The Cathedral is one of the most important architectural monuments in Veliky Novgorod. It is of federal significance and included in the UNESCO World Heritage List. The St. George Cathedral was built in the pre-Mongolian era, in the first half of the 12$^{th}$ century and restored in the 1830s.

In the present work, eleven mortar samples from the St. George Cathedral were studied. Five of them date back to the 12$^{th}$ century, and four – to the 19$^{th}$ century. The research aim is the classification of mortars with unknown dating based on the elemental composition.

Neutron activation analysis was used to determine elemental composition of the mortars. The samples were irradiated using the IREN facility at the Joint Institute for Nuclear Research and the WWR-K reactor at the Institute of Nuclear Physics. Therefore, the mass fractions of 35 elements were obtained.

Statistical treatment (Hierarchical cluster analysis and Principal component analysis) using the R programming language was carried out for sample classification. As a result, the authors assumed, that samples with unknown dating presumably belong to the 19$^{th}$ century mortar group.