

# Ancient manuscripts research using radiations of different spectral ranges and complementary techniques

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The analytical diagnostics of objects of art and cultural heritages becomes more and more demanded in the modern multidisciplinary research. The element mapping, detailed studying of process of writing and formation of a color contrast of letters on the birch bark manuscripts was a main goal and motivation of this research. Multispectral visualization of the hidden textual fragments of the birch bark letter of the 14th century and hidden textual fragments on medieval parchment was also objective of this research.

Synchrotron based SAXS and scanning X-ray fluorescence experiments were carried out at the Kurchatov Synchrotron Radiation Facility, NRC Kurchatov Institute, Moscow, Russia. A set of complementary techniques has been used: the samples were investigated with a scanning electron-ion microscope Versa 3D (FEI) equipped with energy-dispersive X-ray spectrometer (SEM-EDS) under the low-vacuum (40–200 Pa) mode, optical microscopy and profilometry, multispectral photography, Fourier transform infrared spectroscopy (FTIR). These experiments were carried out at the NBICS Center, NRC Kurchatov Institute.

One object of our study was birch bark manuscript of the 14th Century found during excavation in Veliky Novgorod, Russia in October 2016 by an expedition of the Institute of Archaeology, Russian Academy of Sciences (Moscow). It was supposed, that letters are written by ink, that was extremely rare because usually letters was scratched on a birch bark. Another objects of study were textual fragments of medieval parchment manuscript. The text was written by the red color ink.

Textual fragments of ancient parchment and birch bark manuscript, including hidden textual fragments, are elementally mapped and digitally imaged with scanning synchrotron based X-ray fluorescence and multispectral imaging techniques. The collagen structure of the parchment are diagnosed using synchrotron based small-angle X-ray scattering technique.

We carried out, detailed studying of process of writing and formation of a color contrast of letters on birch bark manuscript. We conclude that the letters could have been written on the birch bark using mechanical pressing of the writing instrument during the writing process without using specially prepared ink. The color (light-brown) contrast of letters is connected with the process of natural pigmentation by natural organic pigments, as a result of mechanical destruction of the suberin cell walls structure. To the best of our knowledge, this is the first comprehensive analytical research of a birch bark manuscript as a written cultural heritage object.

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