

# RESEARCH METHODS AND EQUIPMENT

## NEUTRON ACTIVATION ANALYSIS (NAA)

- IREN research facility and setup on beamline 3 of the IBR-2 reactor
- elemental analysis with sensitivity in parts per million (ppm) and, in some cases, parts per billion (ppb)
- mass multi-element analysis
- determination of mass fractions up to 30-40 elements

## PROMPT-GAMMA ACTIVATION ANALYSIS (PGAA)

- setup on beamline 11b of the IBR-2 reactor
- possibility of studying the elemental composition of high-volume samples
- absolutely non-destructive analysis

## X-RAY FLUORESCENT ANALYSIS (XRF)

- wavelength dispersive spectrometer S6 Jaguar (Bruker)
- portable energy dispersive spectrometer Tracer 5i (Bruker)
- analysis in a wide range of element mass fractions

## FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

- infrared spectrometer Invenio-R (Bruker) equipped with a set of accessories for investigation of liquid and solid samples using transmission and attenuated total reflectance (ATR) techniques
- study of the structure of organic and inorganic substances

## RAMAN SPECTROSCOPY

- portable spectrometer equipped with a video microscope
- study of the structure of organic and inorganic substances

## OPTICAL MICROSCOPY

- stereoscopic panoramic microscope MSP-2 (LOMO)
- polarizing microscope Polam-215 (LOMO)
- luminescent microscope Bioscope-3201 (LOMO)
- microscope-camera MK-20 (LOMO)

## STRATIGRAPHY

- preparation of polished cross-sections of painting with further investigation by optical microscopy

## CHEMICAL MICROANALYSIS

- study of the composition of microprobes under a microscope using drop analysis based on sensitive chemical reactions

## STATISTICAL ANALYSIS

- application of bivariate and multivariate statistical methods for data processing

## EQUIPMENT FOR SAMPLE PREPARATION

- water purification system Direct Q5 UV (Merk Millipore)
- planetary mono mill Pulverisette 6 (Fritsch)
- analytical balance AF 225DRCE (Vibra)
- freeze dryer FreeZone (Labconco)

# INVESTIGATION OF CULTURAL HERITAGE AND SOLVING APPLIED PROBLEMS



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## MEDIEVAL WALL PAINTING

### SAMPLES FOR INVESTIGATION:

pigments and plasters of wall painting, mortars from Old Russian buildings

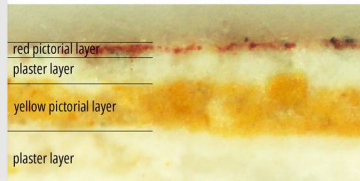
### RECENT STUDIES:

comprehensive study of wall painting cycles of the Cathedrals from Veliky Novgorod, Pskov and Moscow monasteries



**OBJECTIVE:** investigation of pigment composition  
**METHODS:** *in-situ* XRF, FTIR, chemical microanalysis, stratigraphy of polished cross-sections  
**RESULTS:** paint composition (pigments and binders) of unique pre-Mongolian paintings was studied; data will be used for the restoration of the Transfiguration Cathedral of the Mirozhsky Monastery (Pskov, 12<sup>th</sup> c.)

**OBJECTIVE:** study of wall painting technique  
**METHODS:** stratigraphy of polished cross-sections  
**RESULTS:** on the basis of the number and order of the painting layers, it was concluded that mixed (fresco-secco) techniques were used in the unique pre-Mongolian painting of St. George Cathedral of the Yuriev Monastery (Veliky Novgorod, 12<sup>th</sup> c.)



**OBJECTIVE:** digital reconstruction of presumable original coloration of mural fragment  
**METHODS:** XRF, digital photo processing  
**RESULTS:** based on the pigment composition and change in coloration, a presumable original view of the mural fragment of the Smolensk Cathedral of the Novodevichy Convent (Moscow, 16<sup>th</sup> c.) was created

**OBJECTIVE:** comparative analysis of mortars  
**METHODS:** NAA, XRF, chemical microanalysis  
**RESULTS:** according to the component content and ratio of some elements, an assumption was made about the later time of creation of some fragments of medieval buildings in Vladimir, Veliky Novgorod, Yuryev-Polsky



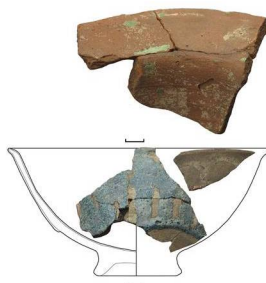
## ARCHAEOLOGICAL SAMPLES

### SAMPLES FOR INVESTIGATION:

ceramic, glass, and metal artifacts

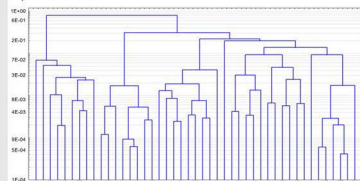
### RECENT STUDIES:

analysis of red clay and kashin ceramics, fragments of glass bracelets and gold jewelry



**OBJECTIVE:** identification of raw material provenance for archaeological ceramic artifacts  
**METHODS:** NAA, XRF  
**RESULTS:** based on the element contents, a conclusion was made about the origin of raw materials (Apennine Peninsula) for the manufacture of antique terracotta found during the construction of the Crimean Bridge

**OBJECTIVE:** formation of reference groups for determination of red clay ceramic manufacture locations  
**METHODS:** NAA, statistical analysis  
**RESULTS:** criteria were found that allow to classify unknown ceramic samples according to their provenance



**OBJECTIVE:** determination of the origin of metal artifacts: natural or artificial  
**METHODS:** NAA, PGAA, XRF  
**RESULTS:** on the basis of mass fractions of certain trace elements, a conclusion was made about the natural origin of the alloy under investigation - electrum

**OBJECTIVE:** identification of manufacturing centers for fragments of glass bracelets  
**METHODS:** NAA  
**RESULTS:** comparison of the obtained data with the recipes of the major glass manufactures makes it possible to conclude about the Old Russian origin of artifacts



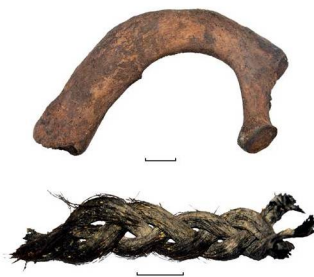
## HUMAN REMAINS

### SAMPLES FOR INVESTIGATION:

bones, hair, teeth, brain fragments, organics from skulls

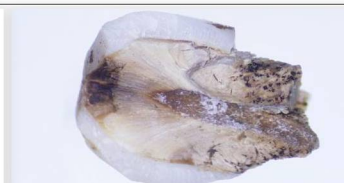
### RECENT STUDIES:

study of the remains of medieval Russian nobility, bones of ancient blacksmiths



**OBJECTIVE:** determination of the mercury and arsenic content - basic of medieval poisons  
**METHODS:** NAA  
**RESULTS:** high mercury content was found in the rib bone of Ivan Ivanovich - the son of Tsar Ivan IV the Terrible which confirms the treatment with mercury ointments

**OBJECTIVE:** distribution of mercury and arsenic along the length of the hair  
**METHODS:** NAA  
**RESULTS:** based on the hair growth rate (1 cm per month), relations between the element content and time to death of the first Russian Tsarina Anastasia Romanovna were plotted



**OBJECTIVE:** creation of a database of the elemental composition of the remains of the medieval nobles  
**METHODS:** NAA  
**RESULTS:** elemental analysis of various remains of ten medieval high-ranking nobles was carried out, work has been initiated on the the creation of a database of the remains of the medieval nobility

**OBJECTIVE:** determination of the content of copper and main trace constituents of copper ores  
**METHODS:** NAA, XRF  
**RESULTS:** copper was found in the remains, which means that the person was a blacksmith, the detection of arsenic suggests a specific source of raw material



## GEOLOGICAL, ALIEN, AND ECOLOGICAL SAMPLES

### SAMPLES FOR INVESTIGATION:

solid emissions from mud volcanos, soils, sediments, rocks, vegetation, air filters, meteorites

### RECENT STUDIES:

environmental research of samples from Egypt and the Czech Republic analysis of characteristics of Azerbaijan mud volcanos, meteorite Chelyabinsk



**OBJECTIVE:** determination of elemental composition, natural gamma activities and microfauna  
**METHODS:** NAA, XRF, gamma-ray spectroscopy, microfaunal analysis  
**RESULTS:** correlation investigation of solid emission elemental compositions was performed for mud volcanos from Shamakhi-Gobustan region of Azerbaijan

**OBJECTIVE:** determination of trace element composition in rocks to detect elements with increased mass fractions  
**METHODS:** NAA, statistical analysis  
**RESULTS:** the fact of enrichment with uranium and thorium of the rocks from Sukari and Hamash gold mines (Red Sea governorate, Egypt) was revealed



**OBJECTIVE:** determination of environmentally hazardous trace element content in samples of marine sediments  
**METHODS:** NAA, statistical analysis  
**RESULTS:** the sources of pollution and the degree of contamination of the marine sediments of the Egyptian Mediterranean coast were identified

**OBJECTIVE:** determination of air metal pollution using air filters  
**METHODS:** NAA, statistical analysis  
**RESULTS:** the source of air pollution in the Czech Republic (Moravian-Silesian Region) was identified to be the transboundary transfer of combustion products of coal used for local heating in Poland

