

## **Further studies on Archaeometry applications of Prompt Gamma Analysis on the upgraded cold neutron beam of the Budapest Research Reactor**

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The main objective of my research in the frame of Bolyai fellowship between 2009 and 2012 was to perform provenance studies various archaeological objects, using neutron-based methods.

The first non-destructive archaeometric studies have been started in 1997 at the Budapest Research Reactor. We have found that PGAA enables to quantitatively determine most of the major- and a few trace components of silicates (flint, obsidian, radiolarite, Seletian porphyry, andesite, basalt, etc.), composite materials (ceramics, glass), alloys (bronze, silver). From the trace elements, those with high neutron absorption cross-section (e.g. B, Sc, V, Cr, Nd, Sm and Gd) can be detected with high efficiency.

The most significant results according to the types of raw materials were the following during the fellowship:

1, Within the provenance research of chipped and polished stone tools, we have achieved significant results in the study of obsidian, Seletian porphyry and of metamorphic rocks (greenschist, blueschist and basalt). Provenance research of high silica silex is more difficult, since the amount of fingerprint-like trace elements were found to be around the detection limit of our PGAA system. Most of the archaeological object and the reference samples have been provided by the Hungarian National Museum, or were procured within bilateral co-operations and field trips with Croatian, Romania, Serbian, Slovakian, Polish and Ukraine partners.

2, Ceramics, as a composite material consists of clay and temper. Based on our experiments, only limited fingerprint-like elements have been found by PGAA that could be used for provenance studies, thus within the fellowship, the ratio of ceramics studies is smaller compared to lithic studies. In a case study, we have investigated the pottery found in a unique single Late Neolithic grave (in Nagytétény, excavated by Sándor Gallus in the 1930s). Four intact ceramic vessels – representing four coeval cultures of the Carpathian Basin (i.e. Bükk, Transdanubian linear pottery (DVK), Zseliz and Vinča cultures) have been studied by PGAA. Based on our results, the DVK vessel is undoubtedly different from the Bükk and Zseliz culture vessels in their compositions.

3, In the archaeometry of glass, the major constituents (Si, Na, K, Ca and Mg), colouring additives (Cu, Mn, Fe, Co, As and Sb), as well as other contaminants (P, S, Cl and Ti) can provide information about the provenance or production centres of the glass. In a long-term cooperation with Polish researchers, intact fragmented medieval and baroque glass objects of European workshops have been studied.

4, Lapis lazuli raw materials from Afghanistan, Pakistan, Ural, Baikal and Chile have been studied by PGAA and neutron diffraction. We aimed to distinguish between the sources, as well as to reveal the “fake” lapis lazuli.

Some representative case studies of archaeometric applications of PGAA are planned to present on a poster.