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How far can we go with activation analytical methods in heritage science?

Determining the elemental composition of artworks and archaeological finds can provide important information for several heritage science research projects. It can play a major role in determining the origin of raw materials used, i.e. in provenance analysis, in identifying workshops, and in certain cases in determining the authenticity of artworks.

In case of stone tools, different sub-types of various rocks, as well as the geographical sources of the lithic raw materials can be identified with varying reliability, based on their fingerprint-like composition. The provenance of archaeological glass can also be successfully determined, despite the fact of recycling. The composition of metal objects, such as bronzes, namely the ratio of alloying metals can be characteristic of the workshop. However, in addition to elemental analysis, the measurement of isotope ratios is also necessary to identify the locations of ores used. In the examples mentioned, the success of provenance analysis depends largely on the number of samples examined, which come from both art objects and raw materials.

A major advantage of neutron activation methods is that neutrons penetrate deeper layers of the samples being examined, thus providing more representative average composition data for the object. Moreover, when using an external neutron beam, it is not necessary to take samples from the object. In addition to activation, neutrons are also suitable for objects'imaging. By combining imaging and elemental analysis, the elemental distribution of complex objects can also be examined.

The obvious disadvantage of neutron methods is that their application requires an intense neutron source, typically a research reactor or a spallation neutron source, which are extremely costly to operate and require serious safety measures. Special attention must be paid to the activation of the irradiated objects and to their possible radiation damage. However, activation analytical tests can often be replaced by using fast and mobile handheld XRF devices.

In most heritage science research, determining the elemental composition alone is not sufficient. To describe the objects as completely as possible, additional structural analysis (using X-rays or neutrons) and, in some cases, molecular spectroscopy might be necessary.

In this presentation, I will primarily focus on examples from research conducted at the Budapest Neutron Centre in Hungary over the past 25 years. The research has been carried out by members of the BNC Heritage Science Group.

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