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Combining neutron methods –a unique science tool kit in artefact analysis

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Nowadays growing interest is devoted to exploration and protection of artefacts belonging to our treasure of Cultural Heritage. The application of analytical tools of natural sciences has become an important field of archaeology by now. The investigations usually concern dating, provenance, manufacturing techniques, workshop affinities, as well as fake identification or preservation of objects. Neutrons are perfect tools of archaeometrical studies due to their non-destructive and non-invasive nature. Various kinds of neutron techniques can be used to explore the compositional or structural features of the samples. Based on the detection of characteristic γ-photons produced in (n, γ) reaction, one can determine the 'bulk'elemental composition of the objects. Or, investigation of neutron scattering patterns gives information on the atomic, molecular or nano-scale structural properties: crystalline/amorphous morphology, phase composition, mechanical strains, impurities, etc. Furthermore, neutron imaging techniques (tomography/radiography) play an important role in the exploration of the deep bulk topology or in-side content of artefacts.
The Budapest Neutron Centre (BNC) has long traditions in application of neutrons for archaeology research. In particular, the Prompt Gamma Activation Analysis (PGAA) group has made a pioneering work to apply this technique to archaeometry. Small Angle Neutron Scattering (SANS) and Neutron Diffraction (ND), Neutron and Gamma Radiography (NGR) facilities have been involved in various archaeological research project, both at national and European level [1]. Since 2009 BNC contributes to the EU FP7 Cultural Heritage Research project called CHARISMA. The project gathers large European museums as well as provides access to a network of large scale facilities; BNC is one of the transnational access providers by the services offered at its neutron facilities: diffractometers (ND), SANS, PGAA stations and imaging facilities. Complementary measurements are offered by the use of External Beam milli-PIXE and compact XRF Spectrometers, microscopes, mass spectrometers etc. also at BNC site.
Several case studies as comprehensive analysis of archaeological objects by combined neutron techniques will be given. For example, manufacturing processes of the earliest Hungarian Bronze Age defensive armour such as helmets, greaves and cuirass were studied by PGAA, PIXE and ToF-ND. Another highlight resulting from a series of neutron studies is the establishing the meteoritic origin of the earliest known iron objects, a set of elongated iron beads, excavated a hundred years ago at Gerzeh, Egypt in a tomb dated to circa 3300 BC. Predating the invention of bloomery smelting by nearly two millennia, they are commonly assumed to be made from meteoritic iron. Our combined neutron measurements have provided unambiguous results to discuss and offer a comprehensive interpretation of the origin and fabrication of these beads and their significance for the history of iron working development [2].
Literature

[1] Kasztovszky Zs, Rosta L; How can neutron contribute to Cultural Heritage Research?; Neutron News, 23, 25-28, 2012
[2] Rehren Th, Jambon A, Káli Gy, Kasztovszky Zs, Kis Z, Kovács I, Maróti B, Martinon-Torres M, Pigott V, Quirke S, Szentmiklósi L, Szőkefalvi-Nagy Z, Mankinds Earliest Iron –Really Meteoritic? In: Braekmans D, Honings, Degryse P (eds), Proc. of ISA2012, the 39th International Symposium on Archaeometry, 28 May - 1 June 2012. Leuven, Belgium p. 248.

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