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Lapis lazuli: The stone of the Antiquity and their origin

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Archaeological objects, like beads, gems, seals and small decorative objects made of lapis lazuli are widely distributed in the ancient East and some date back as early as the second half of the fourth millennium B.C. in Central Asia.
The chemical composition and mineralogy of lapis lazuli has been given considerable attention in the last decades. Non-destructive analytical techniques of archaeological and historical artefacts have gained more attention in archaeometry research. Commonly methods, such as polarising microscope investigations and analytical methods (XRF, INAA) could not solve the lapis lazuli provenance problem since they are more or less destructive. Although XRF can be applied also non-destructively, it is usually restricted to the study of smooth surfaces of restored archaeological objects. However, the non-destructive bulk neutron-based analytical techniques, such as Prompt Gamma Activation Analyses (PGAA), and TOF-Neutron Diffraction supply further potentials for provenance studies. Knowledge of the elemental composition, including major and trace elements, as well as exploring the mineral composition may provide clues concerning the provenance and raw materials. In this project we have systematically investigated lapis lazuli samples from the largest and - from archaeological point of view - the most relevant quarries. Rock samples from Afghanistan, from Lake Baikal, from Pamir Mountains, from Chile and from Ural Mountains have been collected and investigated by instruments of the 10 MW Budapest Research Reactor and the dedicated external milli-beam PIXE (Particle Induced X-ray Emission) spectrometer of Wigner RC. Due to the high penetrability of the neutron, both PGAA and TOF-ND will give the average composition of the bulk material, i.e. of the object as a whole. The unsurpassable advantages of PGAA, TOF-ND and PIXE measurements that they do not require sample preparation; the artefacts can be positioned directly in the neutron beam; they are absolutely non-destructive, Based on some characteristic chemical elements (i.e. S, Cl, Ca, Fe, Si) we may succeed to distinguish between the most relevant quarries and to determine the provenance of some archaeological objects from the near East. Unfortunately, groups of different provenance defined by characteristic elements, overlap on the discrimination diagram, especially for specimens originated from Afghanistan and from the Baikal Lake. In order to clarify this doubtfulness, TOF-ND was recently tested for non-destructively identification of mineral composition characteristic for the provenance. The diffractograms show the structural changes in the lazurite crystals and the mineral composition of the lapis that could be typical for provenance. Also PIXE analyses have been carried out, and information were obtained on the lateral inhomogenity of the elemental composition on millimeter scale.
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Primary author: Dr ZOELDFOELDI, Judit (MPA, Uni Stuttgart)

Co-authors: Dr KÁLI, György (Research Institute for Solid State Physics and Optics); Dr KOVÁCS, Imre (Nuclear Analysis Group, Department of Biophysics, Hungarian Academy of Science); Dr NÖLLER, Renate (Bundesanstalt für Materialforschung und -prüfung); Dr SZŐKEFALVI-NAGY, Zoltán (Nuclear Analysis Group, Department of Biophysics,Hungarian Academy of Science); Dr KASZTOVSZKY, Zsolt (Nuclear Analysis and Radiography Department, MTA Centre for Energy Research)

Presenters: Dr ZOELDFOELDI, Judit (MPA, Uni Stuttgart); Dr KASZTOVSZKY, Zsolt (Nuclear Analysis and Radiography Department, MTA Centre for Energy Research)

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