Summer School on Radiation Physics Applications to Cultural Heritage, Buenos Aires 9-11 March, 2026.

Ion Beam Analysis for provenance investigation of cultural heritage materials

Marta Magalini (marta.magalini@to.infn.it)
INFN-Turin (Italia)

Abstract: Ion Beam Analysis (IBA) comprises powerful non-destructive nuclear techniques that provide complementary insights into samples by simultaneously examining their chemical composition, structural characteristics and luminescent properties. When a microbeam is employed, even very small features can be investigated. For several years, the Solid-State Physics group of the University of Torino, in collaboration with INFN, has applied μ-PIXE (Particle Induced X-ray Emission) and μ-IBIL (Ion Beam-Induced Luminescence) to the investigation of materials relevant to Cultural Heritage research. Concerning provenance studies, trace element concentrations obtained by μ-PIXE can serve as robust provenance markers for both natural materials (such as rocks) and man-made materials (such as pottery).

Two case studies will be discussed, illustrating different analytical approaches and strategies tailored to specific sample types. The first case study will deal with the provenance investigation of raw lapis lazuli material used in antiquity (archaeological samples investigated majorly from the III-I millennium BCE). Since 2008, our group has been developing and refining an analytical provenance protocol based on the identification of chemico-physical markers through the analysis of individual mineral phases (e.g. diopside, pyrite, calcite) within lapis lazuli. These markers have been searched inside reference rocks of well-known origins from mines in Afghanistan, Tajikistan, Siberia, Myanmar and Chile. While measurements on rocks are mainly performed using in-vacuum microbeams (after a proper sample preparation), the protocol can also be applied non-invasively to precious artefacts using in-air microbeams for raw material provenance determination. The second case study will concern man-made materials, specifically black-glaze ware and red figure pottery that were produced in Southern Italian workshops during the 6th to the 4th century BCE. In this case, in-vacuum μ-PIXE was used to analyse both the ceramic body and the micrometric black vitrified layers on red-figured vases, with the aim of discriminating between different production centres.

Intended Audience: students with a background in cultural heritage studies, archaeometry, or applied physics.

Learning Outcomes: Participants will learn strategies for the application of Ion Beam Analysis (in particular PIXE) to different types of materials, understand the differences between in-vacuum and in-air IBA measurements, and explore how data interpretation can be enhanced through unsupervised machine learning algorithms (e.g. Principal Component Analysis).