Re.S.Artes

Le Regard de la Science sur les Arts et le patrimoine culturel

ERDA analysis of rock crystal works of Art: some elements of understanding

Rock crystal is a particular material which does not fit the regular approaches for stones and minerals testing because of its strong resistance to natural weathering phenomena.
So, its study is based on the specific detection of hydration processes that affect its surface, using ERDA non-invasive technique (*Elastic Recoil Detection Analysis).*

For authentication purpose, it is then possible to evaluate the compatibility of the measurements with the expected age of the object:
If we detect significant hydration processes at the surface of a rock crystal, then we can consider that its carving is ancient.

This is a complementary approach to the stylistic study of works: it provides objective information that comes support (or refute) the point of view of the expert.
This study may be supplemented by an analysis of carving marks and deposits that can be put into light at the surface of the material.

Principle

ERDA technique allows to measure the concentration of hydrogen atoms from the surface to the inside part of the rock crystal and then to characterize hydration processes, with no sampling as it is a non-invasive method.
Hydrogen atoms are introduced into the crystal lattice especially with water and humidity of air. Then, their detection at the surface of a rock crystal corresponds to the gradual hydration of material with time.
As phenomena involved develop at molecular scale through long time periods, we can thus determine if the hydration percent measured at the surface and its penetration inside the material can be considered as compatible or not with the presumed antiquity of the carving work. Finally, relevant clues are giving about the period of manufacturing of the object.

Measurements

Upon interaction between a high energy particle and the nucleus of an atom at rest, the trajectories of the particles after impact are determined by the laws of the elastic collision. In an ERDA analysis, we focus on the lighter target atom, hydrogen, with a weight lower than the incident ions, and which is scattered to the front. In addition, by orienting the target surface at grazing incidence angle relative to the initial beam, a part of the hydrogen atoms have enough energy to emerge and then can be seen by a detector.
In front of this detector is placed an absorbent in order to stop the helium ions diffused forwards and let pass only the ejected hydrogen atoms from the sample. Then we obtain an energy spectrum for hydrogen atoms which will correspond to the atomic concentration of the element according to the analyzed depth of material.
The sample is placed in the analysis chamber under a vacuum of 2.10^{-6} torr. The studied area is facing the incident beam particles, which is constituted by a $4He^{+}$ ion flux whose energy equal to 2.2 MeV is issued by the electrostatic accelerator, and forms on the target an incident current of 1.0 nA for a surface analysis of a around one mm².

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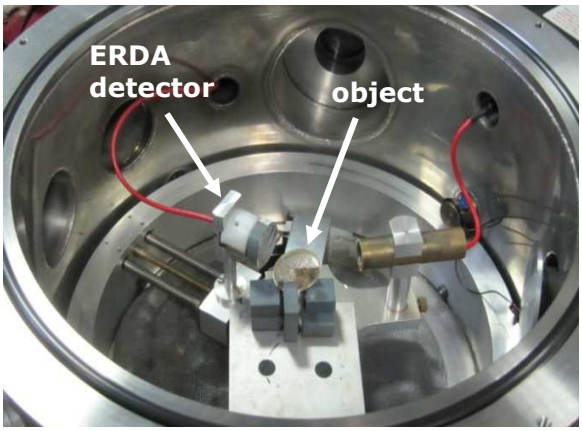
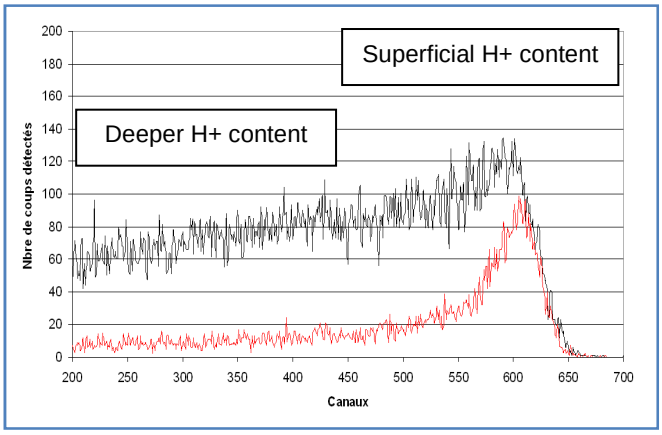
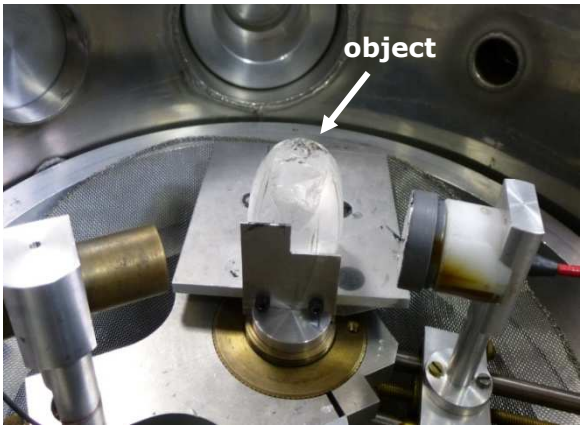
Two examples

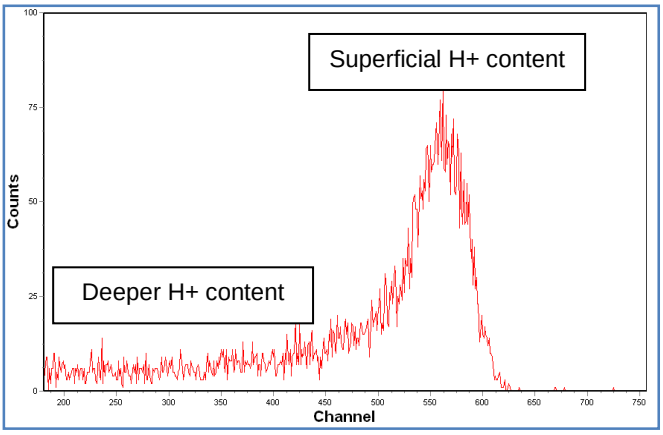




Rock crystal medallion, Central Europe, presumed from Late Roman/Early Christian period

The detection of hydrogen atoms at the surface of the object and its gradual decrease through deeper areas (black curve) indicate that the carving is ancient. The red curve corresponds to a latest punctual work (probable restoration from 19th century).





Rock crystal chess piece, presumed from 10th – 11th centuries AD

The increase of hydrogen content on the surface associated with the high diffusion of this element through the quartz (corresponding to the strong and quick diminution of H+ amount between the surface and the deeper part of the material) indicates that the carving is recent (19th or 20th century).

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