Re.S.Artes

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

Lead-210 authenticity test for objects of art: some elements of understanding

The analysis of metal objects containing lead, typically copper alloys such as bronze or brass, through the quantification of the lead-210 radioactive isotope, allows to determine whether this alloy was manufactured during the 20th century or earlier.

For authentication purpose, it is then possible to evaluate the compatibility of this information with the expected age:
If it contains lead 210, the alloy is considered as a modern one.

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 major and minor constituents of the alloy and corrosion products.
In some cases it will be also necessary to perform X-Ray imaging or CT scan to confirm the homogeneity of the piece and to extrapolate the result to the whole object.

Principle

The so-called Pb 210 test for the authentication of metal objects is based on the disturbance of the radiochemical equilibrium of the uranium decay chain during the smelting process.
Ores and accompanying minerals usually contain small amounts of uranium which produces, during its natural decay, new elements with different geochemical and metallurgical behavior.

While uranium, thorium or radium remain in the slag, chalcophile and siderophile elements, such as bismith and lead, are taken up by the metal phase. Thus the short-lived radionuclide Pb210 (half-life λ = 22,3 years) is efficiently separated from its long-lived ancestors U238 (λ = 4,4.10^9 years) and Ra226 (λ = 1600 years).

The concentration of Pb210 in the alloy, depending on the origin of the ore and the manufacturing process, can not be used for dating. Nevertheless, from its insertion into the metal, its amount decreases by half every 22.3 years. Therefore, its content is virtually undetectable after 130 years. It results from this phenomenon that “old” leads no longer contain enough lead 210 to be detected.

This method thus allows to determine whether the alloy was melted recently (less than 130 years) or earlier. It should however be noted that the absence of Pb 210 is no proof of authenticity, because old metal could have been used to produce objects in modern times.

That is why this measurement gives information about the antiquity of the metal and not the manufacturing of the object.

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Measurements

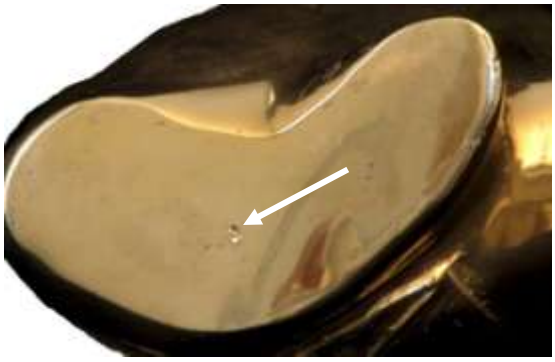
Pb 210 content is determined by alpha-spectrometry, from the activity of a particular element generated during lead decay, the so-called polonium 210 (λ = 138,4 days).

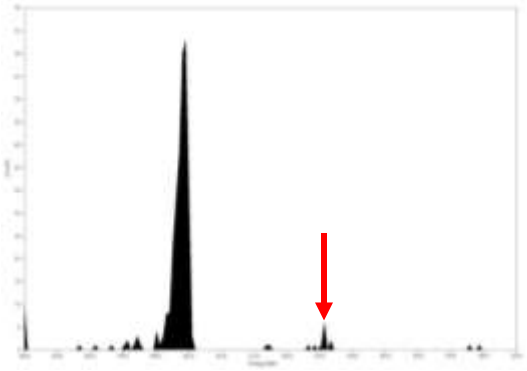
The alpha-spectrometer is composed by a silicon detector with a sensitive area of 450 mm² that allows measurement with a very low background activity and an energy resolution of 20 keV full width at half maximum peak height (FWHM).

The chemicals used are high purity reagents and the water is purified by system based on reverse osmosis.

For the determination of the chemical yield of the separation procedure, a Pb209 tracer is used.

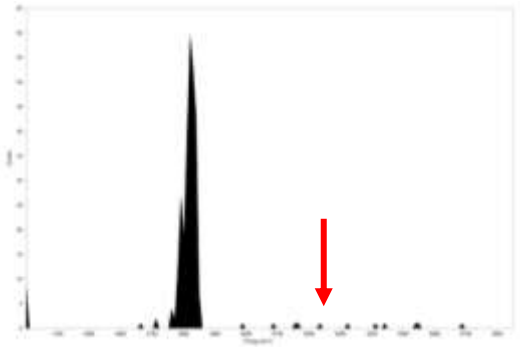
Two examples





Brass sculpture, France, presumed from 20th century AD

The detection of Pb 210, on the base of Po 210 (red arrow), indicates that this object dates from the 20th century and more precisely from the first half of the century.



Bronze bell, Africa, presumed from 17th – 18th centuries AD

The absence of Pb210 (red arrow) indicates that the allow was not melted during the 20th century AD. It could date from the beginning of the 19th century or earlier.

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