

## Neutron diffraction measurements for the characterisation of Italian Celtic coins

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The silver coinage of the ancient Celtic peoples settled in northern Italy is, even now, a topic with many unsolved problems, such as chronology, attributions, relationships between series and emissions through time (from IV to I century B.C.). In order to provide numismatists with new data for metrological studies, which require average weights of the emissions and the knowledge of their compositions, several samples have been analyzed with scientific techniques.

Our research group at the Physics Department (University of Torino, Italy) has carried out neutron diffraction measurements at the ISIS facility (Rutherford Appleton Laboratory), to analyze structural properties and composition of these coins. Neutron diffraction is actually a powerful tool for the analysis of bulky metal objects that cannot be sampled. The instrument used is the TOF diffractometer of the Italian Neutron Experimental Station (INES), equipped with 144 <sup>3</sup>He squashed detectors, grouped in 9 banks, covering a range of about 160 degrees on the horizontal scattering plane. This experimental setup allows to measure a wide d-spacing range (from 0.2 to 12 Å), and is then suitable for most metals. In the analyzed coins two main phases were detected, accordingly to the biphasic diagram for silver-copper alloys, while minor phases (> 0.5 wt.%) are due to alteration phenomena. The d-spacing of the silver (beta) and the copper (alpha) rich phases calculated on the diffraction patterns from the backscattering bank are different from the ones of the pure elements, being smaller and bigger respectively. Thanks to literature data, obtained on certified samples, the relationship between d-spacing and composition has been investigated in order to estimate the elemental composition and then obtain a silver/copper ratio useful for numismatic studies.

The first results presented here allow us to suggest a new organization of the entire north-Italian Celtic coinage, based on the scientific data obtained. The most ancient coins of the series are made of almost pure silver, while coins attributed to Insubres and Boico-Cenomani peoples, which belong to a second stage and are contemporary to each other (III century B.C.), show a lower average silver beta phase composition. Later coins (200-125 B.C.), attributed to the Celtic tribe of the Libui, show an even lower silver content average.

In conclusion, information achieved show the importance of the neutron diffraction technique, which provided data to demonstrate a silver content decline due to inflation and, furthermore, to give elements for the study of metrological relationships with the contemporary Roman Republican currency.

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