



# Compositional and microstructural characterization of Celtic silver coins from northern Italy using neutron diffraction analysis<sup>☆</sup>



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## ARTICLE INFO

### Article history:

Received 18 July 2015

Received in revised form 15 January 2016

Accepted 15 January 2016

Available online 23 January 2016

### Keywords:

Neutron diffraction

Silver

Compositional analysis

Numismatics

Celtic coins

Archaeometry

## ABSTRACT

The silver coinage of Celtic tribes settled in northern Italy (IV–I century B.C.) is a topic characterized by several issues, such as chronology, attributions and relationships between emissions produced in different periods. In order to provide numismatists with new data, several specimens, belonging to different typologies, have been analysed with neutron diffraction technique to overcome surface alteration and to provide bulky compositional and structural information of the coins. Measurements performed with the INES diffractometer at the ISIS facility provided essential data for numismatics research. A clear silver debasement occurring between the first and latter emissions has been traced, due to inflation processes which can be related with the increasing power of Roman Republic in the Cisalpine region. Moreover, compositional data enabled for the first time to identify internal evolutions inside typologies defined by numismatists. The silver loss has also been used to establish a relative chronology between different emissions. Other parameters such as texture index, residual strains and grain dimensions have been useful to understand technical aspects of minting procedures during Iron Age.

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## 1. Introduction

The importance of physico-chemical material characterization in studies on the Celtic silver coinage from northern Italy has been rarely considered. Unlike Greek and Roman coins, which have been analysed with several approaches to answer different historical issues, Celtic coins from this area still lack reliable scientific data. Indeed, the few published compositional information [1] have been carried out on untreated coins with X-ray fluorescence (XRF) technique. However, silver-copper alloy coins, especially those with a fineness < 80 wt.% of silver, have actually been demonstrated to be heavily affected by thick silver-surface-enriched layers (up to 200 μm), so data obtained on unsectioned samples by means of surface techniques, including XRF or PIXE, are not reliable [2–4].

For this reason, a wide characterization project involving the use of neutron-based techniques has been developed. The first compositional results were obtained with Prompt Gamma Activation Analysis (PGAA) and have been recently published [5]. To increase the statistical sample and to investigate also microstructural properties, a bulk and non-destructive technique such as neutron diffraction (ND) has been used in this work for the characterization of a further selection of Celtic coins. Time-of-flight neutron diffraction (TOF-ND) measurements have

been performed with the INES diffractometer at the ISIS facility on our specimens.

TOF-ND technique is a powerful tool for the analysis of metal, especially in archaeometric studies as precious archaeological artefacts can be analysed in air without any sampling or preparation [6,7]. This technique has been often applied for coin characterization in the last years [8–14], and results were very promising for numismatics studies. TOF-ND analysis is able to provide both compositional and structural information. In particular, the possibility to extract information from diffraction patterns concerning texture index, residual strain and grain dimension, has been considered very useful.

This study had therefore a twofold aim. The first was to provide ratios of precious and base metal (silver and copper respectively), to verify whether a debasement was present among coins dated to different periods and to understand their exchange ratios with foreign currency (e.g. Roman and Massalian currency). The second was to bring new data for the understanding of minting procedures during Iron Age, being documentary evidence absent.

## 2. Historical background

The pre-Roman coinage from northern Italy, commonly defined as “Celtic coinage of the Po valley”, collects different series of silver coins, produced by several tribes settled in a wide territory known in the subsequent Roman age as the Cisalpine Gaul. These tribes, either of

<sup>☆</sup> Selected papers presented at TECHNART 2015 Conference, Catania (Italy), April 27–30, 2015.

Celtic or non-Celtic culture, minted their own coinage in a period which spans from the 4th up to the 1st century B.C., even if dating of the first emissions is still debated. They emitted mainly drachms, but some rare fractions (obols, diobols or hemidrachms) are known as well. The silver unit, the drachm, even of different tribes, is always characterized by the imitation of the iconography of Massalia's (present day Marseille, France) heavy drachm, depicting a lion with the ethnic abbreviation  $\mu\text{ΑΣΣΑ}[\text{ΛΙΗΤΩΝ}]$  on reverse and the head of Artemis on the obverse. The reason for this peculiar iconographic choice probably lies in the deep relationships between the city founded by Greeks and the Celts, who were commonly hired by Massalia as mercenaries. The imitative emissions started soon after the minting of Massalia's prototypes and lasted for some centuries, until the Roman conquest of northern Italy (creation of Cisalpine Gaul's province around 89 B.C.) and the definitive introduction of Roman currency.

The study of this Iron Age coinage began only in the second half of XIX century. The first extensive work, by A. Pautasso [15], was published in 1966 and was based almost exclusively on a stylistic study of specimens kept in public and private collections and on the analysis of coins from hoards.

Conclusions by A. Pautasso have been over the last years partially revised, in light of new findings and to the development of artefact distribution maps and stratigraphic excavations. In the last two decades, E.A. Arslan proposed a new historical classification and attribution of these coins [16], based on the evidence of single finds. He developed a new cataloguing grid, suggesting attributions to different human groups (e.g. Cenomanes, Insubres, Libici, Veneti) and making hypotheses concerning the location of the ancient emission centres. He organized the Cisalpine coinage into 22 types of drachmas and 6 types of minor fractions.

Nevertheless, despite the richness of studies published in the last years, some scholars disagree with Arslan's research setting (e.g. M.H. Crawford [17] and G. Gorini [18]) and much work has still to be done in order to fully understand the coin production in Northern Italy during Iron Age, both from an archaeological and a numismatics point of view.

### 3. Samples

This work is focused on the silver unit minted by Cisalpine Celts, the drachm. Results presented in this work are all related to silver drachmas produced in different periods and attributed to different tribes (Fig. 1). They mainly come from two hoards kept at the Museo di Antichità in Torino (Italy): the votive deposit from Serra Riccò (GE), currently consisting of 164 specimens, and the hoard of Biandrate (NO), with 40 coins. A third hoard is kept in the Museo Civico of Casale Monferrato, probably found in Balzola (AL) with 240 coins. Other specimens come from the historical collection of the Museo di Antichità of Torino and from the important Carlo Alberto's royal collection (Medagliere Reale) kept at the Armeria Reale in Torino. In these last cases the provenance has not been recorded.

The analysis has been performed on a selection of 33 specimens coming from all the above-mentioned hoards and collections. The coins selected for the analyses are reported in Table 1 along with their code and their weight. Nonetheless, being the classification non-shared among all the scholars, we will indicate for simplicity's sake the coins on the base of their main stylistic features. According to the shape of the lion, we can divide the Cisalpine coinage into the following main streams, all deriving from the Massalia's heavy drachm (Fig. 1a):

1. Massa  $\alpha$  type (Fig. 1b). These rare drachmas are the first imitations, probably minted by local tribes settled in the surroundings of Massalia. Their average weight is the same as that of the official drachmas (3.6 g). Dating is still controversial and the hypotheses span from 380 B.C. up to 215 B.C.
2. Massa  $\beta$  type (Fig. 1c). This not yet well defined group collects drachmas with a lighter weight (although recalling the heavy



Fig. 1. The heavy drachm of Massalia (a) and imitations. Massa  $\alpha$  type (b), Massa  $\beta$  type (c), "naturalistic-lion" type (d), "scorpion-lion" type (e), "wolf-lion" type (f). All the coins bear the same figures, but with different stylistic features. Reference bars: 1 cm each.

drachm) and different styles. They could be the first imitative coins produced in northern Italy.

3. Naturalistic-lion type (Fig. 1d). This type is present in the most ancient hoards in northern Italy and is often associated with the scorpion-lion type. The lion is depicted as natural. The average weight of these drachmas is 3.0 g and they were produced in northern Italy.
4. Scorpion-lion type (Fig. 1e). Often associated with the previous type, is characterized by a lion which denotes a figurative Latenian culture. The lion has been described as similar to a scorpion. The average weight of these drachmas is 3.0 g and they were produced in northern Italy during III century B.C., as the previous type.
5. Wolf-lion type (Fig. 1f). This type belongs to a second phase of the Cisalpine coinage, when the average weight decreased up to 2.6 g. They were produced in northern Italy from the end of III century B.C. onwards.

### 4. Experimental

TOF-ND measurements have been carried out at the ISIS pulsed neutron source (Rutherford Appleton Laboratory, Chilton-Didcot, UK) using the INES TOF diffractometer of the Italian Neutron Experimental Station. INES is a multipurpose powder neutron diffractometer [19], often used

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