Ancient Coins: Cluster Analysis Applied to Found a Correlation Between Corrosion Process and Burying Soil Characteristics

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Abstract

A series of ancient coins, coming from the archaeological excavation of Palazzo Valentini (Rome), were analysed using different analytical techniques; grounds, both surrounding the coins and far from them, were also analysed in order to find a correlation between the corrosion products covering the coins and the grounds chemical-physical characteristics. Soluble salts content in samples coming from the water-bearing stratum, surfacing in the archaeological site, was also determined. Data were treated by cluster and multivariate analysis that confirmed the above said correlation

Introduction

It is well known the quicker degrade of any materials when exposed to aggressive environment; chemical-physical characteristics of both environment and materials have to be considered in order to find the best conservation conditions for the last. In the case of coins, being metallic objects, the corrosion is the main process through which they degrade; corrosion can spontaneously blocks if a protective patina forms during the process while a complete destruction occurs when a non protective patina forms. The patina is the results of oxidation processes so depending on the alloy composition as well as on the chemical species contained, in our case (buried coins), in the surrounding ground.

Taking into account what above said we used non invasive and semi-invasive analytical techniques to characterise a series of ancient bronze coins and grounds close or far from them but coming from the same archaeological zone.

Materials & Methods

Electronic microscopy coupled to X-ray microanalysis (SEM-EDS) was carried out by means of a Zeiss Evo 60. A portable EDXRF was used for X-ray fluorescence measurements (EIS 35 Kvolt, Amptek X-Ray detectors XR-100CR, Amptek, Multichannel Analyzer MCA 8000A). For X-ray diffraction analysis (XRD) a SEIFERT MZ IV, copper anticatode ($\lambda CuK\alpha$ = 1.542 Å) was used. A Metrohm 761 Compact IC was used for the ionic chromatography (IC).

Coins were found in different stratigraphic units during the excavation carried out under Palazzo Valentini that is located in the centre of Rome, very close to Foro Traiano.

Sample treatment: Coins were washed by deionised water in a Elmasonic S30H ultrasonic bath in successive 10 min cycles; after each washing pH and conductivity were measured and a constant conductivity value after three successive washings was considered as complete cleaning of the coins.

Grounds were sieved at 2 mm and 0.6 g were pressed

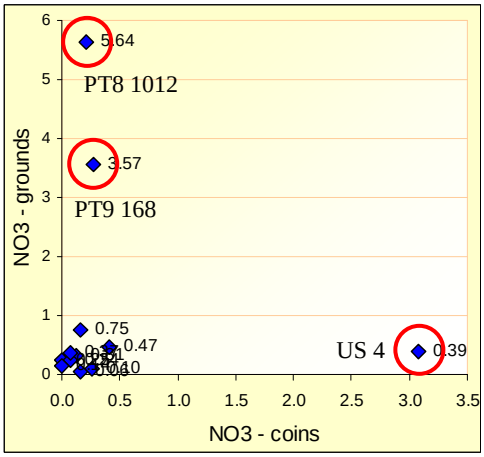

Fig.1; nitrate content in washing waters of coins and grounds

at 10 atm to obtain pastilles to be used for SEM-EDS and XRF analysis. Other sieved portions were pulverised in an agate mortar; aliquots of 250 mg were put in 25 mL deionised water to extract soluble salts to be determined by IC.

Results

The obtained results evidenced the influence of the alkaline grounds on the patina formation; really cerussite is the main corrosion product evidenced by XRD and can be imputed to the presence in the ground of lot of carbonatic fragment such as marble, ceramics and plaster continuously washed away from circulating water. On the other hand, copper, lead and vanadium was found in grounds surrounding coins. Conductivity, pH and soluble salts content of water, coming from washing of both coins and grounds, allow us to separate coins as a function of the different stratigraphic unit where they were found; as an example Fig. 1 shows a correlation diagram between nitrate content in waters coming from washing of coins and grounds. Fig 2 shows how the Hierarchical Cluster Analysis allowed us to group, as triple, compositional data of bulk coin, patina and surrounding grounds. Distances were calculated by City Block, after column centring, using Unweighted Pair Group Average Method. Table 1 reports the chemical elements found in the coin bulk, patina and surrounding ground.

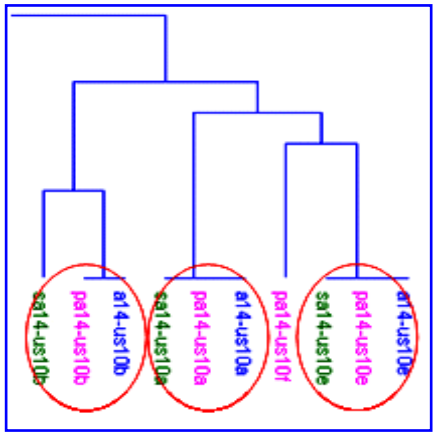

Fig.2; EDS data relative to the composition of coins (blue), patinas (reddish) and grounds (green)

Tab.1 – Chemical elements found on coin bulk, patina and ground of the 12 roman coins. The elements coming from the ground are in blue

xxx = *present* , xx = *frequent* , x = *rare*

Elements	coins	patina	soil
Mg	x	x	xxx
Al	xxx	xxx	xxx
Si	xxx	xxx	xxx
P	xxx	xx	xxx
Cl	xx	x	x
Ca	xxx	xxx	xxx
V	xx	xxx	x
Fe	xx	xx	xxx
Cu	xxx	xxx	x
As	xx	xx	x
Sn	xx	x	-
Pb	xxx	xxx	xx
Na	-	-	xxx
K	-	x	xxx
S	-	-	xx
Ti	-	-	xxx

Conclusions

The aim of the presented research was attained, really the analytical procedures and techniques used to found a correlation between the microenvironment of our sample coins and their degradation state. Really the cluster and multivariate analysis must be recognised as the main tool to obtain such results as a traditional data treatment would be very difficult due to the different kind of data and overall to the big mole of data to be treated.

References

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