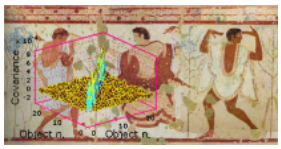

Razors, Horse Bits or Axes; Search of the Different Composition in Common Use Bronze Villanovan Objects (VIII-VII century b.C., Italy) by Multivariate Analysis

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Abstract

More than 14000 fragments of common use bronze objects found more than 130 years ago in the so-called "Ripostiglio di San Francesco" (St. Francesco hoard), in Bologna, analysed by a portable EDXRF, requiring a chemometrics analysis of the metal alloy constituents (Cu, Sn, Pb, Fe, Sb, Ag, As) to try to identify the different composition in function of the destination of use.

Introduction

One of the most interesting discoveries of the final bronze age in Italy is the finding, near Bologna, in 1877 [1], in what then was named hoard of San Francesco from the name of the square place under excavation. Here, was found a great pottery *dolio* of diameter more than 1 meter rather full of bronze fragments. The number of these fragments ranges from 14841 [2] to 14838 [3] and already this shows us the fragmentation of the objects, recognisable in their previous function only after a careful visual analysis and by comparison with other, integer, and already well known to the archaeologists. The discovery is of enormous importance, according to the ref. 2 "constitutes the more bigger storage of the early Italian iron age", since collects items of common use, sometime so utilised to be consumed to be no more suitable and perhaps ready to be remelted to obtain new ones.

Numerically the principal constituents of discovery are the axes, with more than one fourth of the total, followed by the “fibulae” up to cover about half of objects. The other half consists of almost all items used in Villanovan period in Italy up to Iron Age. Objects ornaments as armille, belts studs, laminae, earring pendants, albeit minimally are also present.

In a previous work of two of same authors [4] defined the metal alloy composition by fluorescence induced in the metal atoms lighting with X-ray (EDXRF) a non-destructive technique widely used to study of large bronzes, the

Commonly, and even in this case, analysts prefer to remove the patina of oxides for sampling the metal bulk roding a couple of millimetres in diameter are usually by suitable abrasive systems. The micro-invasive analysis allows to perform many measures in various points of the same sample producing a large number of emission spectra to interpret and then a big amount of data element-concentration%.

Unfortunately, this type of investigation does not provide absolute, quantitative, values but only the relative percentages, the use of reference materials with the same (identical?) composition of the alloy can produce data acceptably semiquantitative useful for the interpretation.

Tab.1 San Francesco hoard, general statistic values of 301 objects

	Cu%	Sn%	Pb%	Fe%	Sb%	Ag%	As%
Smallest value	76.00	0.00	0.00	0.00	0.00	0.00	0.00
largest value	99.10	22.10	9.30	2.00	1.20	0.70	2.10
arithmetic mean	88.74	8.83	1.43	0.48	0.23	0.21	0.07
sample stand. dev.	3.54	3.44	1.17	0.30	0.19	0.12	0.30
median value in list	89.10	8.70	1.20	0.40	0.20	0.20	0.00
most frequently value	90.00	7.20	1.20	0.30	0.20	0.20	0.00
num. of zero values	0	8	13	6	55	120	282

Materials & Methods

One of the problems that we arise in attempting classification when the number of the objects close to 15000 is what sampling design must be used. In this case the objects

have been divided in macro categories and then in homogeneous groups through morphological and functional analysis even if they were broken and damaged.

The objects more represented are the axes (more than 4000), on the contrary are recognisable only some fish hook, there are also 3 iron objects. For the multivariate analysis would be better to have all classes with the same number of objects, but so is the object with fewer attendances that dictates the numerousness. Even following this good choice then the question of what axe must be measured among the 4000 remain. Here a statistic say "simple random sampling with replacement", that is easy and with sample design effect =1.

Needless to say that instead chemometricians often encounter a colleague with the usual phrase "do you think that we can draw out something from this dataset measured last year?", except understand, after, that they have done only measures in the laboratory on finds chosen by others. But return to this case, only a small part of the objects was well morphologically identifiable; 301 items were selected by archaeologists for the measure, including, for example, 16 horse bites and 4 belt plaques. Sampling that looks like a *probability proportionate to size* sampling design.

Results

In Tab. 1 are shown the statistic values of the elements found in alloy. The average values of the 301 objects shows the typical composition of the final Bronze Age in Italy. They revealed the presence of copper lumps (ingot) ready for the foundry with Cu content of even 99%, two razors with 22.1% and 18.2% in Sn and two fibulae with 6.3% of Pb. Worth noting also the almost ubiquitous presence of Fe and almost absence of arsenic but perhaps As was found with difficulty by portable instrumentation in use.

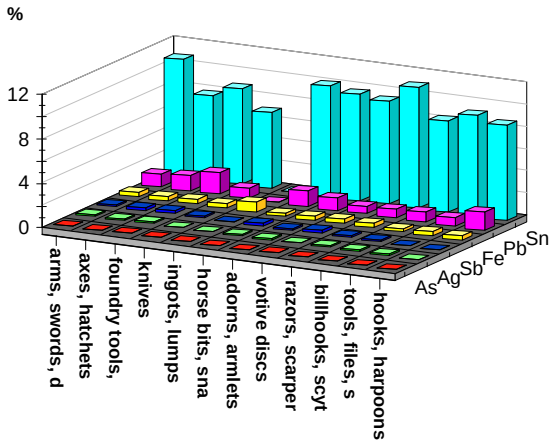

Fig. 1 Mediane values composition of the elements in the classes, omitting the Cu

A good measures data set should contain a certain level of redundancy to allow, post, to calculate the precision of the method, in this case three objects were measured twice, in very close points, and we obtain an error of 1% on Cu, as example.

The chemometric analysis was performed first by various attempts to class visualisation through PCA using all the elements both with leave one out method. The study continues through PCoA using various distances between objects besides the Euclidean. Even an HCA analysis, with Euclidean distances, and nearest neighbour method not has produced recognisable different groups of objects as a function of composition. The composition of the measured elements, mediane, are shown in fig. 1.

Conclusions

As suggested by several author not only the modern society tries to re-use objects and metal alloy. The experimental evidence shows that already during the late Bronze Age, recasting of broken or damaged items was common practice. Experts foundrymen had already discovered how many heat one save using broken objects instead of minerals. The multivariate analysis in this case, using multiple methods, allows to "not" find homogeneous classes confirming the thesis previous stated.

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