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Inductively Coupled Plasma (ICP), Thermogravimetric (TG), Derivative Thermogravimetric (DTG) and Chemometric Study of Fossil Bones From an Archaeological Site

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Abstract

Several fossil bones samples belonging from necropolis of El Geili, in the middle Nile, an important archaeological site, were first of all subjected to TG and DTG analysis and the main steps in the thermogravimetric curves were analyzed. In addition using ICP plasma emission spectroscopy we analyzed the same samples also for their content of calcium, zinc, strontium and results were discussed on the basis of the anthropologic observations to this end reported in literature.

Introduction

Thermogravimetric curves (TG-DTG) of several human fossil bone samples, from the necropolis of El Geili [1] have been recorded. An in-depth analysis of the mass losses as a function of temperature during a linear scan in the range 25-1000 °C was carried out, focusing in particular on the decomposition processes of collagen and carbonate; the main TG/DTG outcomes were then organized in a data matrix that was processed by exploratory chemometric methods. The results obtained were then examined with the aim of formulating an "archaeometric" evaluation of the analysed samples on the basis of the (sometimes conflicting) considerations reported in the literature in this regard. A quantitative analysis of calcium, zinc and strontium content of these samples by ICP was also carried out. Strontium/zinc and calcium/strontium ratios (which can be plotted as binary diagrams) provided a further confirmation to the archaeometric evaluation based on thermal analysis but, above all, allowed to formulate important anthropologic considerations about feeding and sociological asset of the individuals those fossil finds belonged to.

Materials & Methods

Several samples of fossil bones, were subjected to TG and DTG analysis, under an air stream (100 cm^3 min^{-1}) with an heating rate of 10 °C min^{-1}, using a Mettler 50 thermobalance, coupled with a Mettler TG 10-TA processor system. TG-DTG data were processed by PCA analysis using in-house routines written in Matlab (The Mathworks Inc., Natick, MA).
Plasma emission (ICP) measurements were carried out using a Varian Liberty 150 plasma spectrophotometer and performing the mineralization of sample using a MDS-61 D CEM Corporation microwave mineralizer.

Results

Using the main thermal data (temperatures of DTG peaks, mass loss, recorded in principal steps and values of TG residue at 1000 °C), it was possible to assembly a suitable table of numerical data, used as dataset for chemometric processing of data. The PCA representation evidenced a good separation of all the studied samples in two different main clusters, named "cluster 1" and "cluster 2" respectively (see Fig. 1).

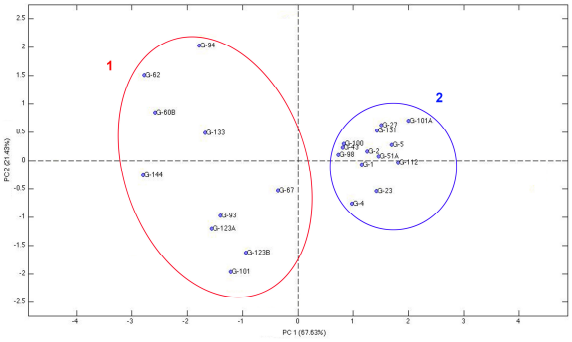

Figure 1 PCA analysis on TG/DTG data showing the presence of two clusters.

The results obtained by ICP (Figures 2 and 3) show

above all that: with the exception of 3 – 4 cases, the ratio Sr/Zn in the different samples is rather similar. In particular, Zn content (apart from 3-4 cases, as said) is in general rather low, while that of Sr results medium-high (Figure 2).

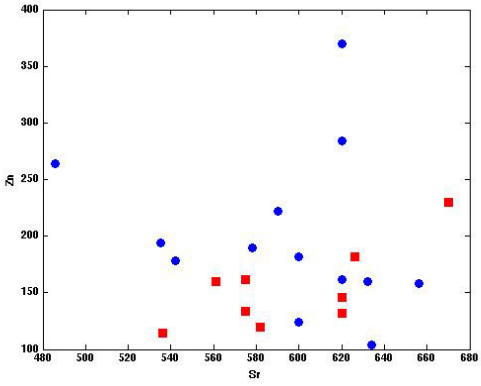

Figure 2 Sr/Zn distribution in bone samples from cluster 1 (red) and 2 (blue)

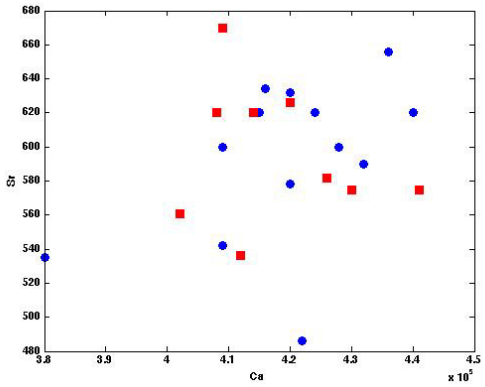

Figure 3 Sr/Ca distribution in bone samples from cluster 1 (red) and 2 (blue)

On the other hand, observing the values of the ratio Sr/Ca, represented in Figure 3, one can observe that the samples are grouped in a rather homogeneous and random fashion.

Conclusions

Probably the separation of samples in two clusters can be attributed to different age of bones from different burials [2, 3], however other researchers [4] hypothesized that also other reasons could be responsible of the differences found in the TG - DTG curves and consequently of the separation in two different classes of the analyzed samples, as was well evidenced by the chemometric representation. The distribution of ICP data, which can be observed in the plot represented in Figure 2, could indicate a predominantly vegetarian alimentation, probably accompanied by significant supply of shellfishes [1]. A more thorough analysis of the plot, however, shows that the 3-4 samples having a significantly higher Zn content all belong to cluster 2; on the other hand, even if the differences cannot be considered highly significant, almost all the samples belonging to cluster 2 appear to have a Zn content slightly higher than those from cluster 1. Also this observation, even if it should be taken very carefully, could mean that samples from cluster 2, i.e. those bones that previous thermoanalytical results suggested as well to be less ancient, probably belong to individuals whose diet, even though still being essentially vegetarian, started to include other different foods. In particular, the 3-4 individuals with the highest Zn content, even seem to be completely out of this kind of feeding, having adopted a more varied diet, richer in shellfishes and perhaps in meat. Trying to interpret also the distribution of data observed in Figure 3 according to what reported in the literature [1], one could affirm that anyway the society of these individuals belonged to wasn't significantly differentiated into social classes yet.

References

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