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Soil chemistry analysis of the Orgéres site (La Thuile, AO - Italy) as a reference for archaeological interpretation

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ABSTRACT
Archaeology is the discipline that studies past human civilizations by collecting, documenting and analysing the traces left by the ancestors. The cross-contamination of different scientific fields such as geology, chemistry and physics endorsed a more accurate analysis of the archaeological sites. This work analysed samples from the archaeological site of Orgères, located near La Thuile (Valle d'Aosta) through the following methodologies: ICP-OES (Inductively Coupled Plasma-Optical Emission Spectroscopy), and CHNS analyser. Inside the site artefacts from the Roman era and structures from the 17th century were found. Results of four different areas were compared with samples taken outside the site. The main soil constituents were analysed through principal component analysis that allowed an in-depth study of the relationships between the samples and highlighted the variables that most influenced the observed relationships. By evaluating the data set, it has been possible to date the site and the activities that were carried out at the archaeological site.

Section: RESEARCH PAPER

Keywords: Alpine archaeology; elemental analyses; Middle Ages; Roman Age; ethnoarchaeology

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1. INTRODUCTION

The interpretation of human behaviour from the material remains of artifacts deposited on the landscape is the lifeblood of archaeology.

Soil analysis supports archaeologists to define the human attitude. Different chemical elements can be incorporated into an archaeological deposit via fuel ash, manures, midden deposits, food and crop processing residues, domestic residues, building materials, and industrial and manufacturing waste.

Indeed, several studies confirm that the concentration of certain chemical elements in the soil was enhanced by past human activity [1]. These studies mostly used multi-element analysis techniques to establish elemental patterns for selected areas within and around the archaeological sites.

Interpretation of element concentration patterns in archaeological soils is problematic because of the complexity of site use history and the effects of post-depositional soil processes [2]-[3]. Many human activities, including food preparation, hearths, middening and manuring, craft working and industrial processes, can add element loadings to cultivated soils, occupation deposits and floor layers. However, the concentrations of analytes in the soil can be related to natural and anthropogenic processes. Background variation related to geological, pedological, and hydrological differences can determine patterns of element concentrations. Soil formation processes following deposition, such as podzolisation, leaching, and gleying, can influence the retention and redistribution of anthropogenic element loads in the soil [4].

The relocation of a particular place is often due to wars, to the insufficient fertility of the soil, or to the shifting of trade routes [5]. Following the displacement, the settlement begins to degrade and, after several years, the terrain will have a markedly different appearance to how it looked before, but also to how the land would have looked if man had never colonised it. In fact, it is possible to notice an inhibited growth of vegetation in places where buildings stood, or the presence of plants that have grown on ruins. Moreover, in presence of an abandoned settlement, the actual composition of the soil will also show a noticeable difference [6].

Human activities cause changes, sometimes relevant, in the soil chemistry, allowing scientists to understand when the site hosted humans. Despite the complex nature of soil geochemical loads, there have been some studies that have validated the use of multi-element soil analysis in archaeological contexts. Recent ethnographic studies have confirmed that soils and pavement layers from different functional areas often have different chemical signatures [4], [7].

The use of multi-element analysis (ICP-AES, ICP-MS and XRF) for soil saples is a very useful technique that provides rapid, precise and complete results. Several studies have shown that patterns of element concentration often reflect known archaeology. Aluminum enters the composition of numerous minerals such as jasper (α-AlOOH), corundum (Al_2O_3), gibbsite [γ-$Al(OH)_3$], feldspars and all phyllosilicates. The total Al content in the soil is inherited from the pedogenetic substrate; however, only the most mobile Al fractions (exchangeable, complexed with organic matter, constituent of minerals with reduced crystalline order) play an important role in the properties of a soil [8].

High concentration of barium (Ba), phosphorus (P) and manganese (Mn) at Piedras Negras in Guatemala were associated with areas of organic waste disposal while mercury (Hg) and lead (Pb) concentrations were associated with craft production areas [9]. Some studies correlate the amount of iron ores on the reconstruction of ancient metallurgical processes and iron provenance [10].

Detailed role of soil calcium (Ca) as of food preparation areas of the past, its presence in charcoal ash and its high content in teeth and bones make its investigation crucial for scientific research on soil in archaeology [11]. Carbon (C) in inorganic form associated with calcium is characteristic of the use, in the area, of lime [12].

Given this precondition, this study aims to provide scientific support to the team of archaeologists working on the site by analysing the main constituent elements of the soil and delineating characteristic areas. Finally, by consulting the archaeologists, the goal is to define what the different areas of the site were used for.

2. METHODS

2.1. Study area

The Project Orgères (La Thuile, AO) is the point of reference for the Valdostan alpine archaeology, not only for its interdisciplinary nature. Located at Pont Serrand, Orgères is a high-altitude settlement (1665 m), at the confluence of the Orgères valley with Chavannes valley, on the alternative route that leads to the Piccolo San Bernardo (Figure 1).

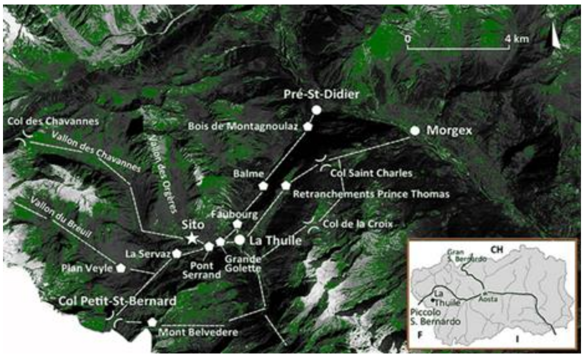

Figure 1. The territory of Orgères (S. Pinnacoli, RAVA). Site placement (star in the map) in relation to La Thuile.

Excavation activities began in 2014, in the framework of a project funded by the Department of Historical Studies at the University of Turin. The study aimed at enhancing, preserving and protecting the historical heritage of this place and the community living there [13].

The name Orgères derives from the village close to the site. It is located along the road leading to the Col des Chavannes, specifically along the farm road from the nearby village of Pont Serrand, located at the intersection of the vallon des Orgères with the vallon des Chavannes. This route represents an alternative route to the col du petit Saint Bernard close to this site.

Studies carried out up to now show that the site was continuously occupied from the I to the XVIII century A.D., so, from the Roman period until the period of the war between the French and the Savoyards. As the site was inhabited for a long period of time by different civilizations, an accurate dating is difficult. Mountain sites generally show a strong reuse of existing buildings, and the construction materials (usually stone, used for the foundations, and wood for the upper parts) are not so different between the various eras.

The main differences found among the various periods are the cut and positioning of the stones. This fact allows us to hypothesise the dating of the different areas, suggested by the stratigraphic excavation and the materials used [14]. Four archaeologically interpreted excavation contexts were examined to obtain an overview of the settlement of the territory (Figure 2).

These excavation areas (E.a) are divided into:

I. *Excavation area A*

This area, dated as Roman phase, consists of two masonry structures with rough and rounded boulders of medium size. These constructions were built without the use of mortar. They can be dated between the 1st and 3rd century A.D. due to the presence of Po Valley and Gallic sealed pottery found in the foundations.

II. *Excavation area C*

The early medieval portion is represented by a rectangular room (essay C), with a simple wall texture and evident

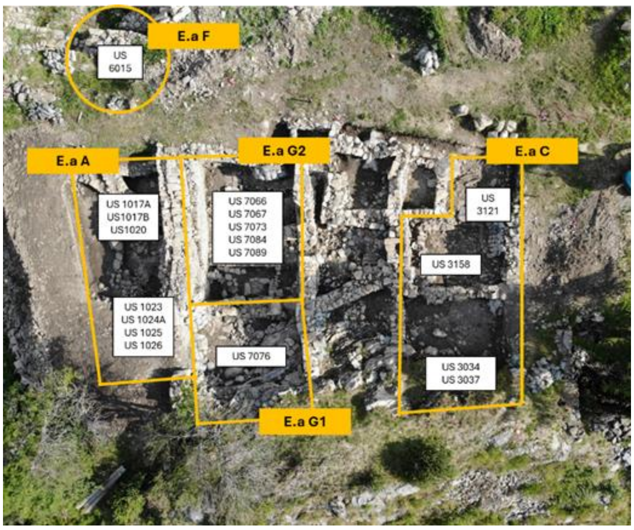

Figure 2. Excavation plan reported the four excavation areas (E.a). Each E.a is delimited by the orange lines drawn on the map. Inside the white boxes are the codes of the site's sample.

rearrangement of the foundations, probably related to damage caused by natural factors. The foundations are made of stone and dry-bonded, arranged both horizontally and shear. In the southern part of the building, a fireplace was found embedded in a very compact clay soil.

III. *Excavation area G2-G1*

The essay has a low medieval date. It appears as a large rectangular building, which was built on top of Roman structures, covering them. On the eastern side, there are three entrances, equally distanced from each other. This entire area is well finished and even the masonry, although dry-built, has fairly regular rows of slightly hewn stones and the use of reinforcement. One of the hypotheses made is that it was a 'casaforte', a place where the person who controlled the territory resided. Given the size of the area, the essay was divided into two zones G2 and G1.

IV. *Excavation area F*

Assay F appears to be separate from the rest of the structure and may suggest a greater extent of the site.

The dating of the area is unknown due to the collapse of the site soon after its discovery, which made stratigraphic excavation difficult. Given the several tools found, we could assume that the area was devoted to metal forging.

2.2. Soil sampling procedure

Samples were taken at different points of the archaeological site. Sampling was carried out in agreement with the archaeologists, based on the points of interest in accordance with the historical framework. The samples were taken at a depth of at least 1.5 metres above the ground. Soils samples were previously sieved with a 5 mm sieve to remove coarser material and vegetation residues.

No quartering was carried out as the sample arrived at the laboratory represents the total amount excavated, from which the analyses were based. A total of thirteen soil samples were taken from the four excavation areas.

Four soil samples consider as “blank” were taken sufficiently far from the site itself and in areas of low anthropisation. For the sampling of blanks, the Little St. Bernard was taken as a reference point, sampling in the 4 opposite directions. For this samples, the first 15 to 20 cm of soil was removed, taking the layer below the turf.

All samples, after preliminary sieving, were placed in plastic bags and catalogued indicating: the area from which they were taken, an indicative code (US) of the position of the sample, the date of discovery, and a brief description of the specific site. The samples, before being analysed, were dried in an oven at 60 °C for one day to remove most of the water.

On the dried samples, sieving was carried out at 600 and 90 μm preceded by sieving at 2 mm. Table 1 reports the list of samples analysed.

2.3. Microwave Digester System

Mineralisation was carried out using a microwave digester (ethos-UP, Milestone). Vessels were washed with deionised water before use and then left to dry in an oven at 120 °C overnight.

According to the official EPA 3051 method, the amount of sample to be used is 0.25 g. Samples sieved to 90 μm, were weighed directly into the vessels by adding 10 ml of aqua regia (reagent). The microwave allows to set the desired temperature, the time required to reach it and the subsequent isotherm.

Table 1. Sample's list. Code explanation: US = Stratigraphic units; first two number = identifies the layer; other two number = identifies different sample inside the E.a.; letter = to differentiate samples taken in the same layer.

Site’s Code Sample	Excavation Area	Description
US1017B	A	Carbon soil
US1017A	A	Black Soil near to Red one
US1020	A	Red soil
US 1023	A	
US 1024 A	A	
US 1025	A	Compact soil
US 1026	A	Red soil 2
US3034	C	Fireplace part
US3037	C	Fireplace
US 3121	C2	Soil with holes
US3158	C	Clay
US 7066	G2	Filler layer
US 7067	G2	Level layer 2
US 7073	G2	Green soil
US 7076	G1	Collapse soil
US 7084	G2	Fireplace area
US 7089	G2	Sand
US 6015	F	Forge
REFERENCE 1		Soil Piccolo San Bernardo
REFERENCE 2		Grass Piccolo S. Bernardo
REFERENCE 3		Soil Pic. S. Bernardo Lake
REFERENCE 4		Soil Verney lake

The protocol applied includes: 15 minutes to reach the temperature of 200 °C and a 15-minute isotherm for a total of 30 minutes. In both, the maximum power used is 1800 W.

After 1 hour of cooling up to room temperature, the samples were filtered through quick filter paper and the filtrate was made up to a volume of 50 mL with deionised water.

2.4. ICP-OES analysis

Based on literature studies, the following elements were identified as priorities for the analysis of soils from archaeological excavations: Al (aluminium), Ba (barium), Ca (calcium), Cd (cadmium), Co (cobalt), Cr (chromium), Cu (copper), Fe (iron), K (potassium), Li (lithium), Mg (magnesium), Mn (manganese), Na (sodium), Ni (nickel), P (phosphorus), Pb (lead), S (sulphur), Sr (strontium), Ti (titanium), Zn (zinc).

Samples obtained from the mineralization’s were analysed by ICP-OES (Optima 7000, Perkin Elmer, Connecticut, US) atomic emission spectroscopy (wavelength of elements studied with ICP are reported in the Supplementary materials). For each analyte a calibration curve was constructed.

For a clear exposition of results, elements are divided into 4 groups:

- Macro-elements: Al, K, Fe, Ca;
- Trace-elements: Cu, Pb, Co, Cr, Ni ;
- Antropic-elements: Mg, Na, Mn, P, S;
- Base-elements: Ti, Sr, Zn, Ba.

For each E.a, the groups of elements useful for soil analysis purposes will be reported. Results are reported in $mg_{elements}/kg_{soil}$.

2.5. Elemental analysis

Elemental analysis was carried out using (FlashSmart™ Elemental Analyzer Thermo, Massachusetts, US). For each sample, 2.5 mg is weighed into a small tin container. The catalyst (vanadium pentoxide) required for complete combustion of the sample is also inserted into the tin container (2.5 mg). Results are expressed in % of C, H, N, S in relation to the exact weight of the sample.

2.6. Data analysis

The data collected through ICP-OES analysis were reprocessed through principal component analysis (PCA) using CAT, Chemometric Agile Tool [15].

PCA allows for representing data from multivariate space with a lower number of new variables, called principal components (PC), which are composed of linear combination of the original variables. By means of PCA, it is possible to study relationships among samples and to highlight the variables that mostly affect the observed relationships. For the analysis of PCA, the metal concentration values obtained from the ICP-OES analysis were used as factors. The sample coding of the analysed samples can be found in the supplementary materials.

3. RESULTS AND DISCUSSION

Chemical analyses results will be treated separately by excavation area. Results are reported divided into two graphs: the first one discusses the macro-elements (Al, K, Fe, Ca), while the second one discusses the trace-elements (Cu, Pb, Co, Cr, Ni).

3.1. Excavation area A

The first excavation area considered is excavation area "A". Results are reported in Figure 3.

Analysis of the macro-elements shows a clear separation between the first four samples and the last three analysed. In particular, a different concentration of Fe, K, and Ca was ascertained depending on the sampling area. As reported, in the same E.a. there are soils with different compositions.
Higher macro-element concentrations in the samples (US 1024A – US 1025 – US 1026) are indicative of an iron-rich clay type. The presence of aluminium, iron, potassium and magnesium (Mg reported in supplementary material) could indicate an iron-processing activity that left slag and forging wood ash in the soil. In contrast, the samples of the first group show higher concentrations of copper and lead, which is almost not found in the last three samples. This could indicate the use of tools made from these materials in this area of the site.

Considering Figure 3, high concentrations of copper, lead and phosphorus (P reported in supplementary materials) can be observed in the first three samples, indicating a cooking activity using copper- and lead-based utensils.

3.2. Excavation area C

The second excavation area considered is excavation area “C”. Results are reported in Figure 4.

Based on the results obtained for excavation area C, the samples can be divided into three groups:

1. the fireplace area (samples US 3034 – US 3037)
2. the hole zone (sample US 3121)
3. clay zone (sample US 3158)

Indeed, samples from the fireplace area show high concentrations of potassium in the ashes of wood used to fuel the fireplace. In addition, the high concentration of sodium may be due to the preparation of food in this area. It can also be assumed that these fireplaces were not only used for cooking, but also for metal forging given the high concentrations of Ni, Pb, Co. The high concentration of Cu may confirm both hypothesised uses of the area: either as cooking utensils or for metalworking.

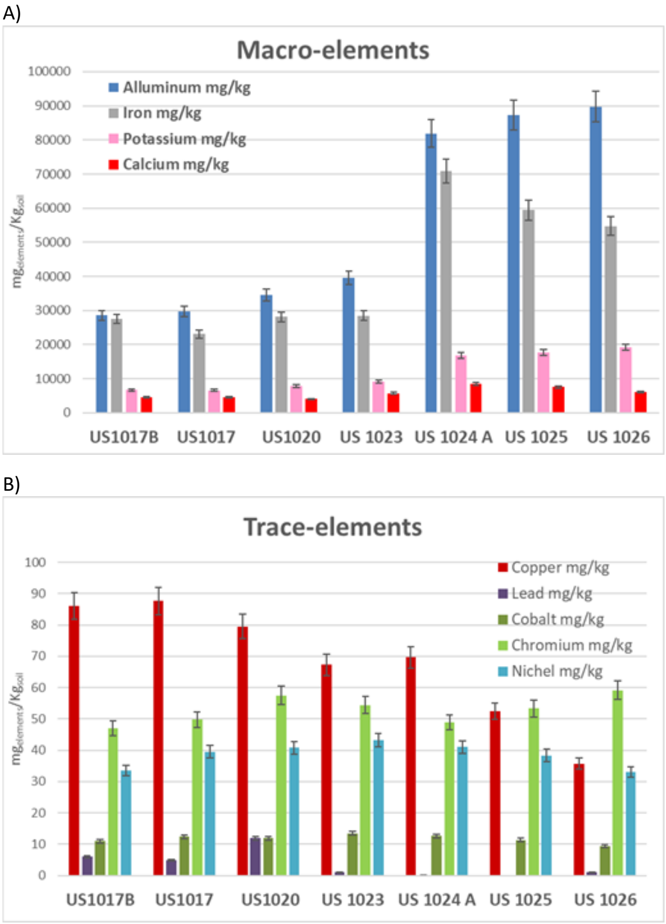

Figure 3. Excavation Area A samples, Graph A): Al, Fe, K, Ca. Graph B): Cu, Pb, Co, Cr, Ni. Results are presented as the mean of three measures ± standard deviation.

Sample 3121 shows high concentrations of phosphorus, sulphur and copper. The presence of these elements can be related to the possible leathers tanning. In fact, phosphorus is an element found in animal tissue, sulphur was used for tanning and copper from the tools used for processing. These hypotheses can be further supported by the presence of holes in the area, probably related to a light wooden structure used for spreading and drying hides. Finally, residues from the processing of hides or the use of tannins for tanning could justify the increased concentration of carbon and nitrogen in the soil (Figure 5).

3.3. Excavation area G

The third excavation area considered is the area “G”, results are reported in Figure 6 and Figure 7. Unlike previous excavation areas, in excavation area "G" a low amount of aluminium and a high concentration of calcium can be seen in all samples, an indication that this is no longer a clay soil, but a limestone one, due to the lime use (as mortar) for plaster. Calcium amount is particularly visible in the "Green soil" (US 7073) and "Sand" (US 7089) samples. It is assumed that there was a part of lime mortar pavement in these specific places, which is now crumbled.

Samples calcium level dated in the early medieval period (mid-13th - 14th century) US 7073 - 7089 is higher than all the others: this leads to the assumption that the flooring, or the rooms masonry, might have been built with a different technique. Assuming that in earlier times the dry technique was used for

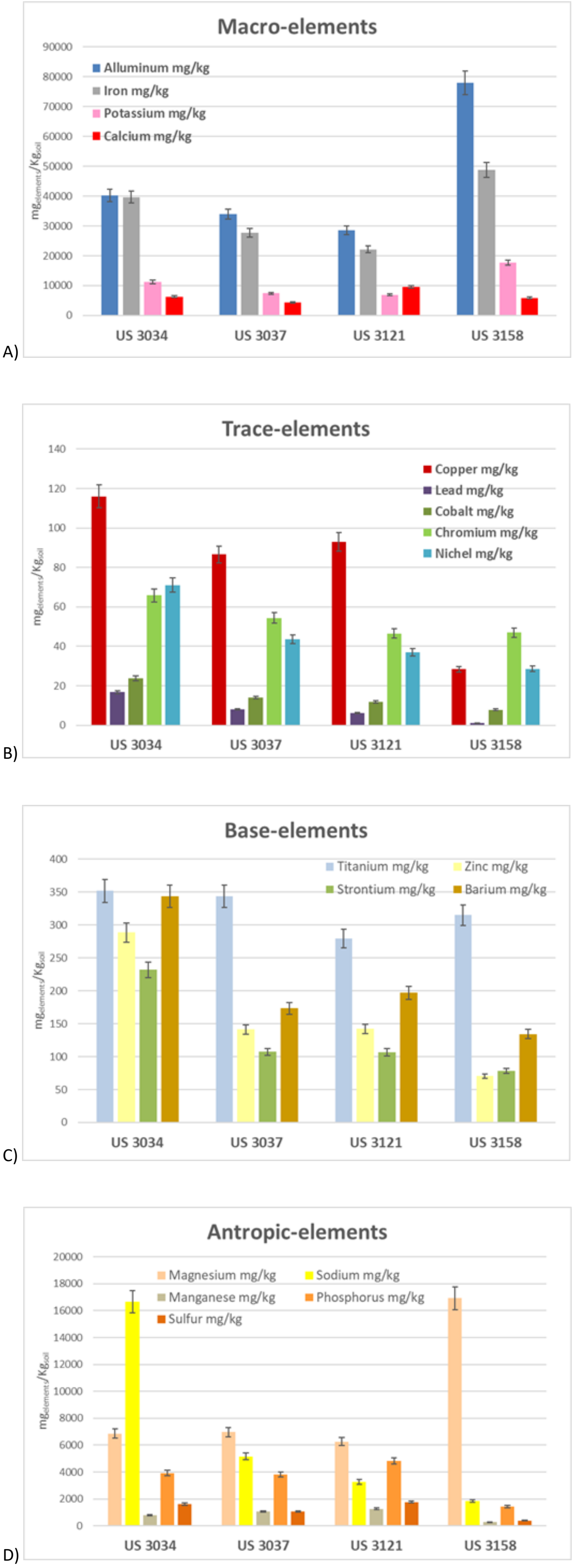

Figure 4. All elements of excavation Area C samples, Graph A): Al, Fe, K, Ca. Graph B): Cu, Pb, Co, Cr, Ni. Graph C): Ti, Sr, Zn, Ba Graph D): Mg, Na, Mn, K, S. Results are presented as the mean of three measures ± standard deviation.

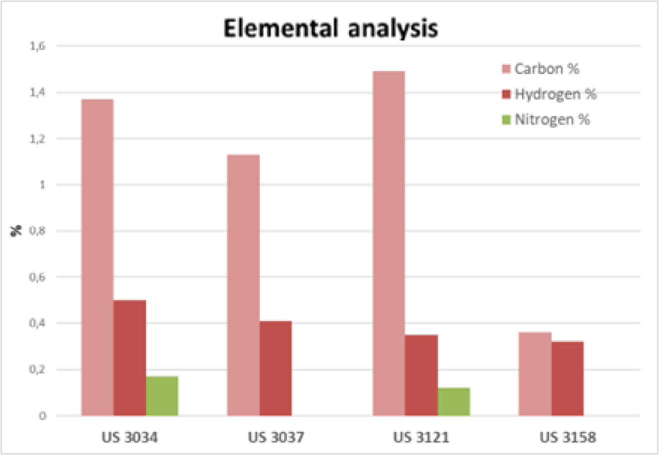

Figure 5. Results of the percentage of C, N and nitrogen in the E.a. C.

masonry and cobblestone pavements, a more accurate finishing of the interior elevations with a plaster layer cannot be ruled out.

"Collapse Soil" (US 7076) sample shows interesting information: the high concentration of iron, phosphorus and sodium presupposes that it could be a landfill, where animal and plant wastes were dumped along with other materials. The collapse of the masonry or soil sealed the area, making the soil rich in the above-mentioned elements.

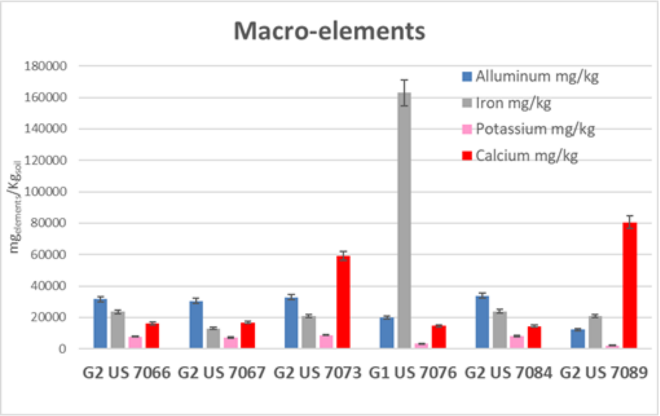

Figure 6. Macro-elements in the excavation Area G: Al, Fe, K, Ca. Results are presented as the mean of three measures ± standard deviation.

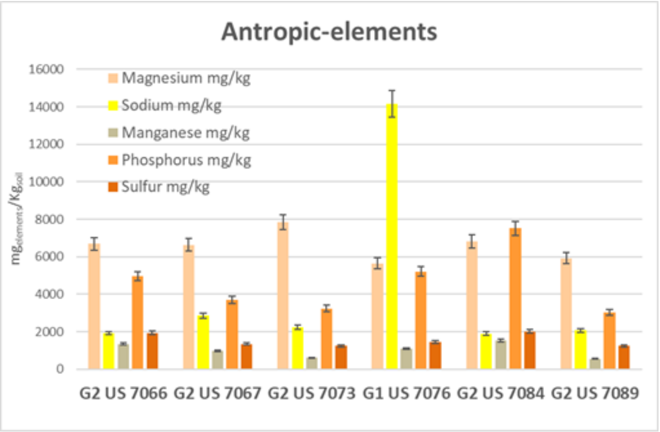

Figure 7. Antropic-elements in the excavation Area G: Mg, Na, Mn, K, S. Results are presented as the mean of three measures ± standard deviation.

3.4. Excavation area F

The last E.a is the area F. Excavation area F is isolated from the rest of the site buildings, and it has no precise dating for the time being. However, based on stratigraphic relationships, it is placed in a chronological span between the end of the 15th century and the Ligne construction in 1690. In this excavation area, the concentration of metals in the samples analysed is similar to the values found in the remaining excavation points.

According to preliminary analyses carried out by archaeologists, it was assumed that the area was used as a forge. Accordingly, it may be interesting to assess the iron concentration found in that E.a against the value found in the other excavation area analysed (Figure 8).

As reported, the iron concentration in this area is not significantly higher. Conversely, concentrations are lower than those found in E.a A, probably used as a processing area, and E.a. G (US 7076), which can be traced back to a landfill site. Therefore, evaluating the results obtained, we cannot confirm the hypothesis of the use of this area as a forge.

3.5. Reference samples

Reference samples were collected in an area of public grassland around the reference point (Little St. Bernard). The analysis of the metals in the reference samples made it possible to support several hypotheses regarding the habits of the areas of the site studied.

First, there is a significantly lower concentration of Mn (Figure 9), an element that is related to iron-working slag. As can be seen from the graph, Mn concentrations are clearly higher inside the site. These values may be related to the need for disposing of the ash after processing and its spreading on the site. A comparison of the Al and Mg data from the E.a A and the reference samples (Figure 10 and Figure 11) further endorses the former results. As can be seen, the values of samples 1024 - 1025 - 1026 are, for both elements, higher than those of the reference. Since it was assumed that iron was processed in E.a A, discordant values support the thesis previously presented.

The soils analysed as blanks show similar concentrations of Al, except for the sample taken near the lake. The lake is at a lower altitude than the small St. Bernard and the other samples taken. The soil was sampled at the base of the wall, approximately 50 metres from the lake. Consequently, as the mountain walls are snow-covered in winter, the phenomenon of soil leaching occurs. As a results, the samples taken at the base of the mountain result in higher concentrations of macro-elements.

Additionally, it is interesting to compare the values obtained for Na and P (Figure 12). These elements are found in areas used for cooking. As previously reported, high concentrations of these elements were found in sample US 3034 of E.a C. As shown in the graph, the values of these elements are lower in the reference samples, supporting the previous thesis of possible presence of fireplaces in the area C of the site.

Finally, also for sample G, the comparison with the reference samples supports the theses previously discussed. As mentioned above, the high concentration of Ca in the samples US 7073 - 7089 suggests that the flooring, or the masonry of the rooms,

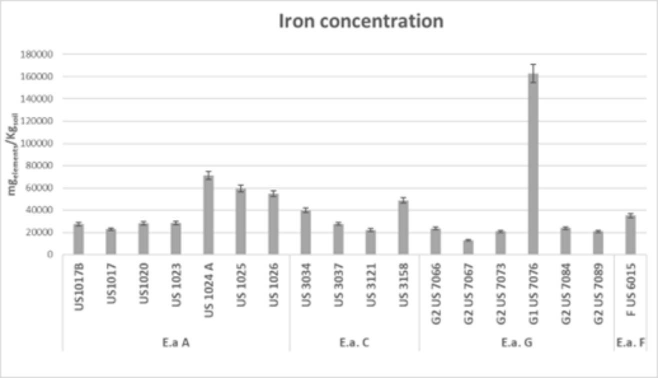

Figure 8. Iron concentration in the four excavations area evaluated. Results are presented as the mean of three measures ± standard deviation.

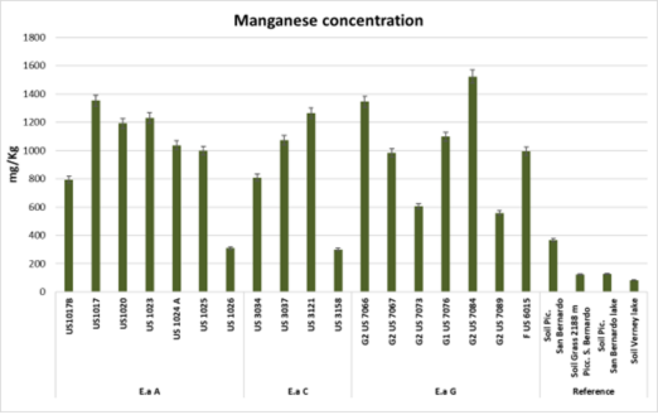

Figure 9. Comparison of manganese concentration of samples inside and outside the site. Results are presented as the mean of three measures ± standard deviation.

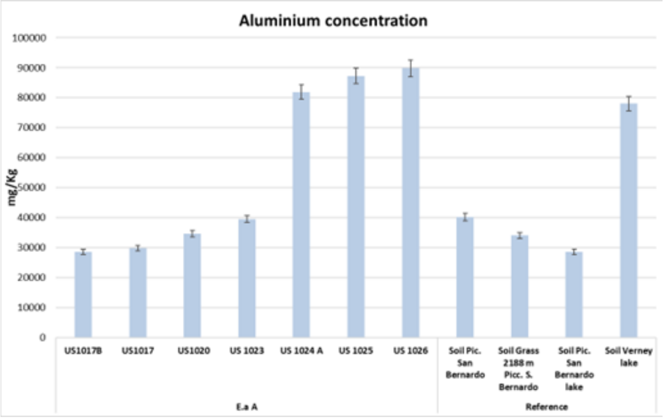

Figure 10. Comparison of aluminium concentration between E.a A and reference samples. Results are presented as the mean of three measures ± standard deviation.

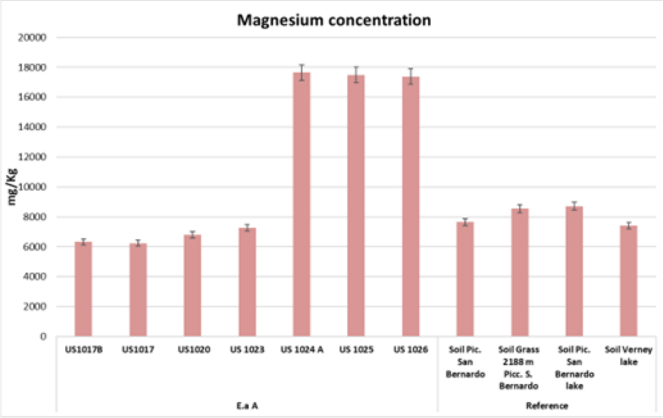

Figure 11. Comparison of magnesium concentration between E.a A and reference samples. Results are presented as the mean of three measures ± standard deviation.

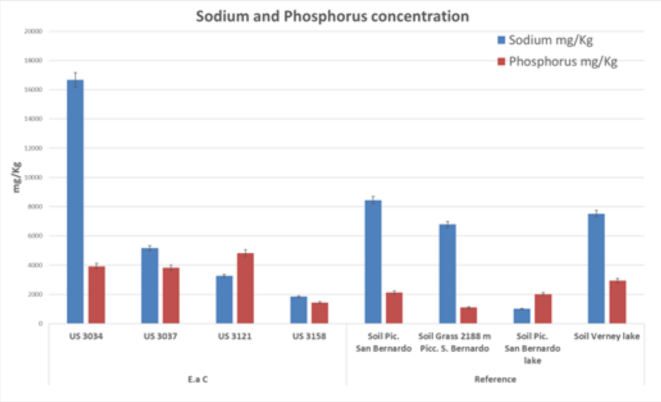

Figure 12. Comparison of sodium and phosphorus concentration between E.a C and reference samples. Results are presented as the mean of three measures ± standard deviation.

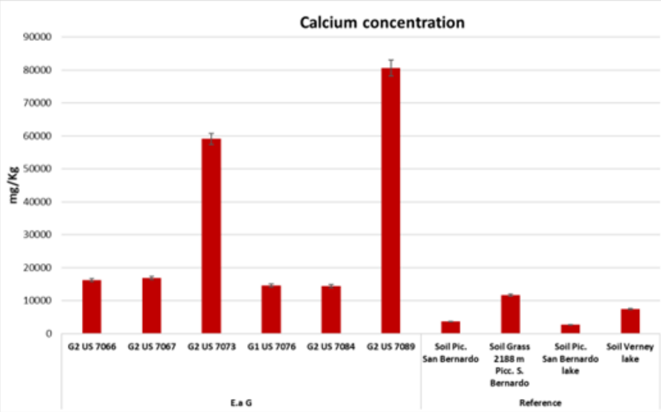

Figure 13. Comparison of calcium concentration between E.a G and reference samples. Results are presented as the mean of three measures ± standard deviation.

may have been constructed with a different Ca-based technique. In fact, a comparison with the values found for this element in the reference samples, higher concentrations are showed by the samples in the E.a G than in the external samples (Figure 13).

3.6. Principal component analysis (PCA)

The objective of the analysis was to extract the determining factors to reduce the number of variables and to study relationships among samples and variables. As reported in Figure 14, 5 components explain 80% of the system. Below are the obtained before world biplot diagrams considering PC1/PC2 and PC1/PC3.

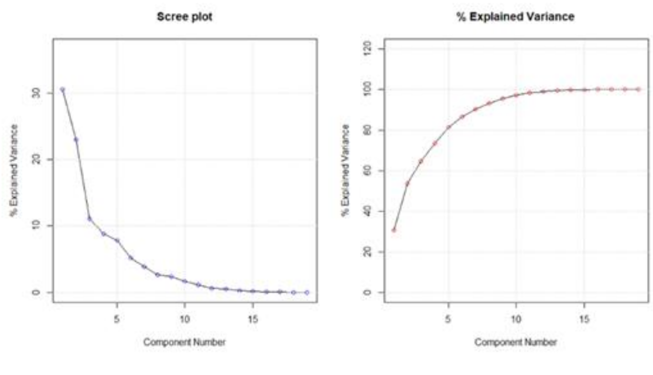

Figure 14. Scree plot of principal component and % explained variance.

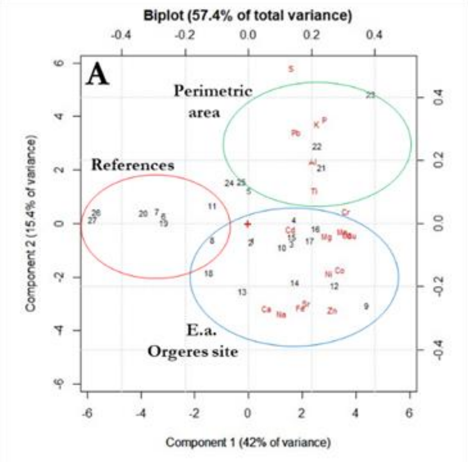

Figure 15. Biplot A for component PC1 and PC2. In red the elements using as factors for the PCA analysis; the numbers in the graph correspond to the analysed samples.

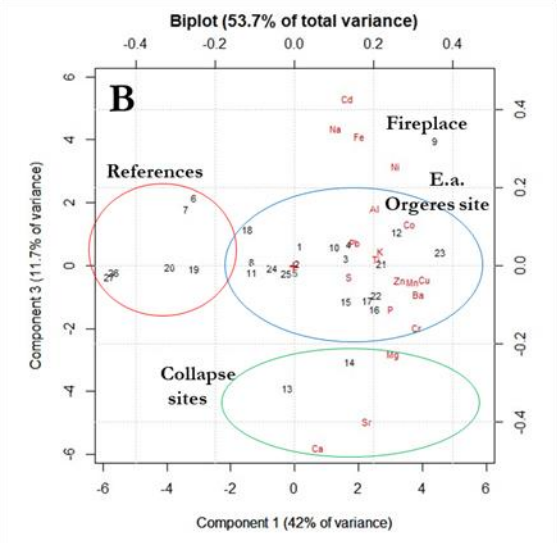

Figure 16. Biplot B for component PC1 and PC3. In red the elements using as factors for the PCA analysis; the numbers in the graph correspond to the analysed samples.

The first biplot (Figure 15) shows that the variables are arranged at always positive PC1 values, while on PC2 the metallic elements are differentiated from those more likely to derive from organic sources (S and P).

The distribution of the factors analysed by means of these two components makes it possible to group the samples studied into macro-groups. Samples taken as reference are all located for negative PC1 values. Whereas samples collected within the site are located at positive PC1 and negative PC2, an area where mainly metal analytes can be found. These considerations confirm what was mentioned above: the possibility of metal processing activity inside the site and the possible scattering of slag inside it.

This hypothesis can also be confirmed by comparison with the samples taken in the perimeter area (data not reported) of the site, which are grouped by positive PC1 and PC2 values characterised by the presence of metals derive from organic source.

On the second biplot (Figure 16), alkaline earth elements are distinguished at negative PC3 values. From the values of the scores (coordinates of the samples in the new reference system defined by the principal components), clusters of samples with similarities can be identified.

The clusters of samples identified allow us to draft some important considerations regarding the activities of the site.

Firstly, the difference between the reference (red cluster) and the in-situ samples (blue cluster) is again noticeable. In fact, a cluster is seen for negative PC1 values that collects reference samples, which do not display common characters with the other samples considered.

Particularly distinctive is sample No. 9, defined as “Fireplace” (E.a. C US 3034 – 3037). Metal analysis of these samples showed high concentrations of metals such as Na, K. These results suggested the possibility of a fireplace. Finally, a cluster characterised by high concentrations of alkaline-earth metal is identified. The samples present in this cluster refer to an area defined as 'collapse soils' (E.a. G) characterised by the collapse of a masonry that probably sealed the area, making the soil rich in anthropic elements.

4. CONCLUSION

Considering the results reported, the study of the samples under examination allowed accurate delineation of the areas of the archaeological site of Orgères. Aluminium is present as clays formed by the degrading of aluminosilicate-based rocks. Clays are in the excavation, outer points, and reference samples. Calcium differentiates the different areas of the site used for permanent or seasonal habitation. The paving of seasonal sites was mainly of dry stone (Roman period or Savoy defence line), while in the medieval period lime was used for paving, masonry reinforcement and plastering.

Potassium and sodium levels indicate that most of these elements are present in soil minerals but, an increase in them indicates the presence of hearth ash and cooking activity. Similar consideration can be done for phosphorus and sulfur, but it should be considered that these two elements are also derived from the decomposition of animal or plant tissues indicating the presence of a landfill or leather processing area.

Iron and manganese are present in the clays, but as mentioned before, they can be derived from iron processing activity. Copper is present in all the excavation areas. Copper as a natural rock element is poorly soluble. The relatively high values recorded in the excavation areas indicate the use of the metal for the manufacture of utensils or vases.

Lead is present in the most superficial layers of excavation areas A, C, and G. The presence of lead in the reference samples is mainly due to anthropogenic origin and can be traced back to vehicular traffic. Carbon is mainly found in the form of inorganic carbon associated with calcium. Calcium in the form of calcium carbonate (resulting from the use of lime) is mainly registered in excavation area G. Another source of carbon is the carbon residues from the hearths, as in excavation area C. High amounts of organic carbon are found in the outer samples and in the voids due to the presence of plant residues. The lowest values are found in excavation area A.

In conclusion, it can be said that the elemental analysis turned out to be very effective for soil characterization. By analysing some of the main metals, it is possible to draw some important considerations regarding anthropogenic activities. In particular, following activities can be assumed within the areas of the site:

- Excavation area A: divided into cooking activities; and metalworking activities.
- Excavation area G2 characterised by a limestone soil that presumes the presence of lime-based masonry works
- Excavation area G1 considered to be the landfill site given the high concentrations of anthropic elements.
- Excavation area C divided into 3 zones:
  - leather processing area;
  - clay zone;
  - fireplace.
- Excavation area F not used as a forge.

A comprehensive map of site activity is given in the supplementary materials.

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