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INTERPRETING SOILS: ARCHAEOLOGY AND CHEMICAL ANALYSIS @ORGÉRES SITE (LA THUILE, AO - ITALY)

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***Abstract* – Orgères' site (La Thuile-AO- 1665m.) is located at the beginning of the Chavannes valley, an alternative road to the Petit St. Bernard pass. The alpine context is difficult to interpret due to continuous reuse of structures from earlier periods to the uninterrupted construction, and the modest amount of archaeological material. This accomplishes several issues not only for re-proposing a precise chronology (derived through very meticulous stratigraphic excavation), but also the intended use of rooms or stratigraphic units. Some excavation areas were initially interpreted through comparison with other contexts. thanks to ethnoarchaeology, but especially to chemical laboratory analysis gave voice to these hypotheses.**

I. INTRODUCTION

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

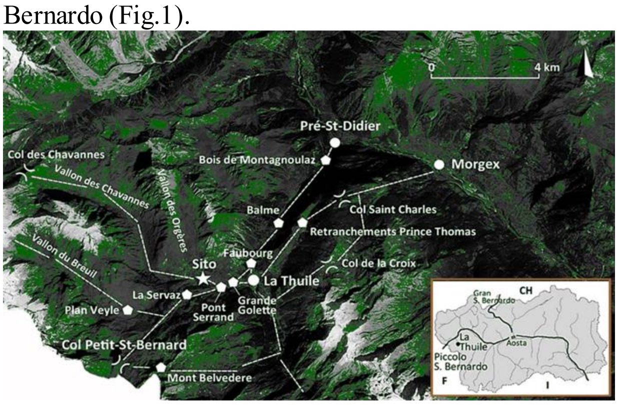

Fig. 1. The territory of Orgères (S. Pinnacoli, RAVA)

The following will examine four excavation contexts interpreted archaeologically [1-2] based on comparisons with both other coeval archaeological contexts and suggestions drawn from ethnoarchaeology.

A. Half XIV Century Phase

Phase of the mid-14th century, an outer area characterized by some small stake holes arranged in a parallel fashion, likely referable to a light structure used to dry organic materials, was identified. This area with these holes (US 3121) is a layer of soil used to level earlier structures, enriched in animal bones with traces of butchering and skinning.

B. Roman/Pre-roman phase

This area has been interpreted as a very rudimentary forge: it is a reddish layer rich in iron flakes in the center, a flat stone with remarkable burn marks.

C. Early Medieval Phase (half XIII-XIV Century)

A fortified house functional for territory and valley economy control by the local lordship was investigated. It is a building stone built, of about 6.00/6.50m of height calculated based on the mighty collapse (250 cubic meters). The materials found within this environment denote a certain social level, as the construction details. Larch rooting was found wooden floorboards were nailed. Chemical analysis provided useful information on several stages of restoration of the flooring itself.

Fig 2. Excavation plan.

D. Fireplaces

Several fireplaces were identified in the excavation area: analysis distinguished those related to domestic use from those also used for some production activities.

II. MATERIAL AND METHODS

Alpine archeology requires the support of laboratory analysis and a constant comparison with scientific and territorial disciplines: in archaeological research and chemical data [3]. Several soil samples were taken inside and outside the excavation site to understand whether soil composition has been altered by anthropogenic activity and to better understand the function and role of the Orgères site. Based on literature studies [4], the following elements were identified as priorities for the analysis of soils from archaeological excavations: Al (aluminum), 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 (sulfur), Si (silicon), Sr (strontium), Ti (titanium), Zn (zinc) and Sn (tin). These elements may be proper to the rock substrate that formed soil basic skeleton, or they may be derived from anthropogenic activity. Generally, the rock constituents are firmly bound together: to break down such sediment requires a very strong acid attack to bring them into solution. On the other hand, anthropogenic element derivation is more easily solubilized and brought into solution by a medium to high strength extractive. Some elements of both anthropogenic and natural derivation can be easily solubilized with weak extractives such as very dilute acid solutions. Their ease of passing into solution is very important from the environmental point of view since they are so easily mobile and bioavailable and enter easily in the food chain.

Three different acid attacks were used for element fractionation study, choosing aqua regia as the strongest extractant, which brings into solution all elements except those bound to silicates. Concentrated nitric acid (HNO_3) was used as a medium-to-high strength extractant but is poorly efficient with several elements such as Al, Cr and Ti. For those that are easily soluble, a dilute acid solution of nitric acid (HNO_3 0.032 M) was used, which maximized the extraction of anthropogenic and more soluble elements than crustal ones. Samples obtained from the different mineralization's were analyzed by ICP-OES atomic emission spectroscopy. The samples were taken at different points of archaeological site, according to historical framework interest's point. For samples extracted outside the site, 15 to 20 cm of soil was removed, taking the layer below the turf. A total of 19 soil samples were taken in the excavation (Tab.1), 5 from outside the site and 4 blanks sufficiently far from the site itself and in areas of low anthropic contamination. The samples after preliminary sieving are cataloged indicating the reference excavation area, an indicative code (US), and the date of discovery. After being dried in an oven at 60 °C for one day, sieving was performed at 90 μm. (Fig.3)

Fig. 3. Sampling Procedure and Soils Samples sieved 90 μM.

Table 1: Sample's list

Site's Code Sample	Excavation Area	Description
US1017B	A	Carbon soil
US1017	A	Black Soil near to
US1020	A	Red soil
Outside Area A	A	Outside near to Area
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	G2	Collapse soil
US 7084	G2	Fireplace area
US 7089	G2	Sand
US 6015	F	Forge

OUTSIDE 1.1	Soil near 2^ Ligne
OUTSIDE 1.2	Soil near Ligne
OUTSIDE 1.3	Ligne under larch
OUTSIDE 1.4	Grass EST
OUTSIDE 2.1	Grass Ovest
REFERENCE 1	Soil Piccolo San
REFERENCE 2	Grass Piccolo S.
REFERENCE 3	Soil Pic. S. Bernardo
REFERENCE 4	Soil Verney lake

III. RESULTS AND DISCUSSION

Chemical analyses results will be treated separately by excavation area, and for presentation's ease those obtained with aqua regia will be considered: given the strength of the extractant these samples can be considered "totals" of the elements present in the soil under investigation. The first excavation area considered is excavation area "A" with the following samples:

Table 2: Sample's list – Excavation area A samples

Site's Code Sample	**Site**	**Description**
US1017B	A	Carbon soil
US1017	A	Black Soil near to Red one
US1020	A	Red soil
Outside Area A	A	Outside near to Area A
US 1023	A	
US 1024 A	A	
US 1025	A	Compact soil
US 1026	A	Red soil 2

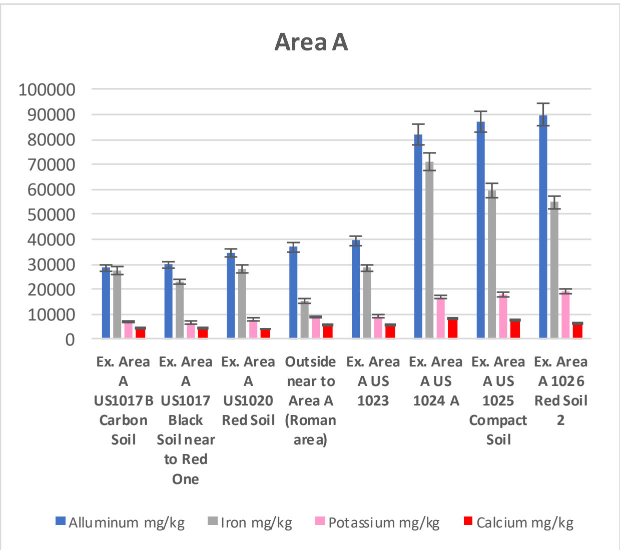

Fig. 4. Excavation Area A Samples Graph – Al, Fe, K, Ca.

A clear separation can be seen between the first four samples (US 1017B Carbon Soil, US 1017 Black Soil, US 1020 Red Soil, Outside Sample) and the last three (US 1024A, US 1025 Compact Soil, US 1026 Red Soil): aluminum, iron, potassium, calcium shows lower concentrations in the first four samples, indicating a different soil type than in the layers below. On the other hand, the last three samples in the graph show high levels of aluminum, iron and potassium indicative of an iron-rich clay type. Iron and potassium presence could indicate an iron-processing activity in the soil stratification, processing slag and forging wood ash. In Fig. 5 in the first sample is remarkable the lead concentration, which is almost totally absent in the last three samples. This could indicate the use of copper and lead tools; on the other hand, phosphorus higher levels could be ascribable to animal remains.

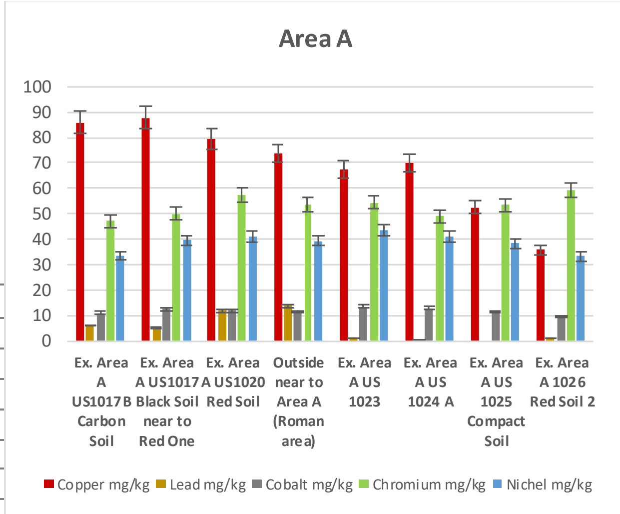

Fig. 5. Excavation area A Samples Graph – Cu, Pb, Co, Cr, Ni.

The following samples were considered for the "C" excavation area:

Table 3: Sample's list – Excavation area C samples

Site's Code Sample	**Excavation Area**	**Description**
US3034	C	Fireplace part
US3037	C	Fireplace
US 3121	C2	Soil with holes
US3158	C	Clay
US 6015	F	Forge

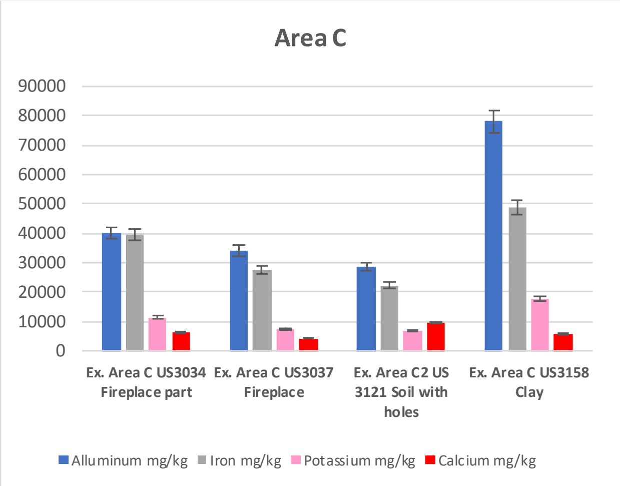

Fig. 6. Excavation area C Samples Graph – Al, Fe, K, Ca.

From the excavation area C graph, aluminum and iron are prevalent in sample "US3158 clay" and samples "US3034 Fireplace part" and "US3037 Fireplace" which probably made of clay. However, when compared with the aluminum levels, higher concurrences of iron occur at the fireplace. A higher concentration of potassium, and particularly sodium, can be seen near the fireplace (US 3034 and US 3037), due to the presence of wood ash and domestic use of fireplace (presumably cooking). Phosphorus and potassium are in high concentrations compared to all other samples would ascertain the thesis validity, considering the necessity to use wood fuel for that purpose.

Fireplace (US 3034) might have been used not only for cooking activities, but also, for metal processing. For this reason, it was deeply investigated analyzing the presence of trace elements. As for sample US 3121, a relevant amount of phosphorus, calcium, carbon, nitrogen and sulfur in the layer with holes is indicative of possible processing and tanning of hides. The arrangement of holes in such an order can be traced to a light wooden structure in order to be able to spread the hides to dry) for processing the hides, later arranged to dry. Residues from processing hides or the use of tannins for tanning hides, could account for the increased concentration of carbon and nitrogen in the soil. The following samples were considered for excavation areas "G" and "F":

Table 4: Sample's list – Excavation area G and F samples

Site's Code Sample	Excavation Area	Description
US 7066	G2	Filler layer
US 7067	G2	Level layer 2
US 7073	G2	Green soil
US 7076	G2	Collapse soil
US 7084	G2	Fireplace area
US 7089	G2	Sand

Unlike previous excavation areas, in excavation area "G" a low amount of aluminum 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 and masonry as a cast for pavement building. Calcium amount is particularly visible in the "Green soil" and "Sand" 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 7076 - 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 masonry and cobblestone pavements, a more accurate finishing of the interior elevations with a plaster layer cannot be ruled out.

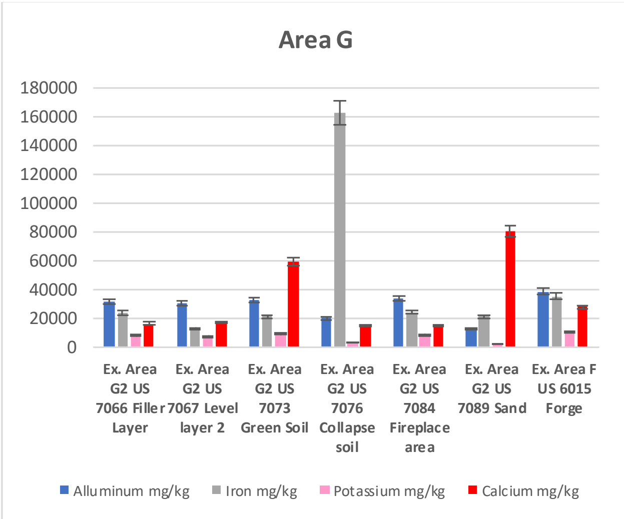

Fig. 7. Excavation area G Samples Graph – Al, Fe, K, Ca.

"Collapse Soil" 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.

The "Fireplace area" and "Level layer" samples are very similar to each other, showing high concentrations of elements closely related to cooking activity, such as phosphorus and carbon.

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. The excavation area peculiarity is that the samples concentration of almost all the elements taken partly mirrors that found in the remaining excavation points.

For the points outside the excavation, the following samples were taken into consideration:

Table 5: Sample's list – Outside samples

Site's Code Sample	Excavation Area	Description
OUTSIDE 1.1		Soil near 2^ Ligne
OUTSIDE 1.2		Soil near Ligne
OUTSIDE 1.3		Ligne under larch
OUTSIDE 1.4		Grass EST
OUTSIDE 2.1		Grass Ovest

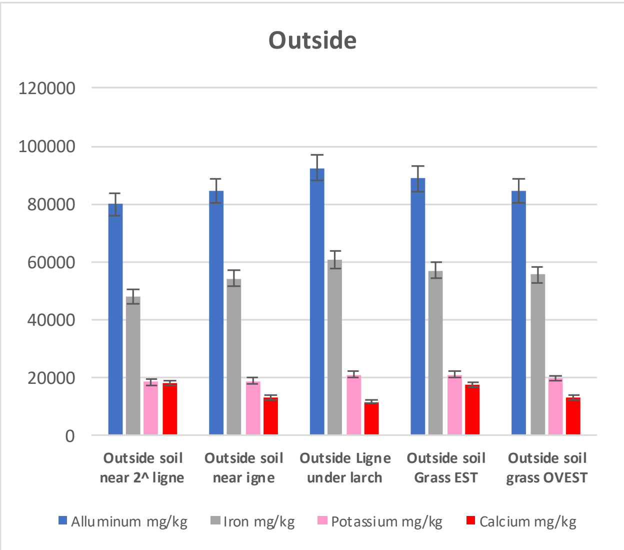

Fig. 8. Outside Samples Graph – Al, Fe, K, Ca.

Sampling points outside the excavation were chosen within a maximum radius of ~100 meters from the site. The soil was taken at a depth of at least 20 centimeters after removal of any vegetation. The rather high aluminum and iron concentrations, very similar to each other, points out that this is a predominantly clayey soil with some percentage of limestone. Similar concentrations of aluminum (and, consequently, clay) can be found in excavation area "A" in US 1024, US 1025 and US1026 and in the clay of essay "C" US 3158. The above suggests that this is the natural composition of the area and that these points represent the original soil of the site. Similar discussion can be made for potassium, which is also naturally present in the rocks of the area. Samples calcium value analyzed is slightly higher than in excavation areas "A" and "C," but significantly lower than in excavation area "G,": this could be related to lime use that has changed the soil composition. Phosphorus, sodium and sulfur values are compatible with a pasture-used agricultural soil. Among heavy metals, more significant amounts of copper and lead can be noted. Higher copper values compared to reference samples, could result from land agricultural use such as vines cultivation or fruit and vegetables that require copper treatments. This hypothesis is further supported by some rather soluble sulfates in soil. The lead can only be partly attributable to the nature of the soil; more likely it is due to anthropogenic activity in the use of this metal. Particularly anomalous is "Outside soil Grass West" sample with a high concentration of lead: a possible hypothesis could lead back to past use of the site as a military polygon. Elements such as titanium, zinc, strontium, and barium were also detected, and they have concentrations comparable to each other and in line with those in the area. As references the following samples are considered:

Table 6: Sample's list – Reference samples

Site's Code Sample	Excavation Area	Description
REFERENCE		Soil Piccolo San Bernardo
REFERENCE		Grass Pic. S. Bernardo
REFERENCE		Soil Pic. S. Bernardo Lake
REFERENCE		Soil Verney lake

Regarding aluminum, iron, potassium and calcium composition there is little variation. Lower values of these elements are recorded in the soil near Lake Verney, probably due to water runoff from the lake. Similar situation is recorded for elements such as magnesium, manganese, phosphorus, sodium and sulfur. Higher phosphorus and lower sulfur values in soils adjacent to the two bodies of water can be attributed to the presence of aquatic life forms. Regarding heavy metal concentrations, of note is the presence of lead in the two samples Piccolo San Bernardo 2188m and Soil Pond Piccolo San Bernardo, which are closer to the road. The presence of lead may be attributable to vehicular traffic and the past use of leaded gasoline.

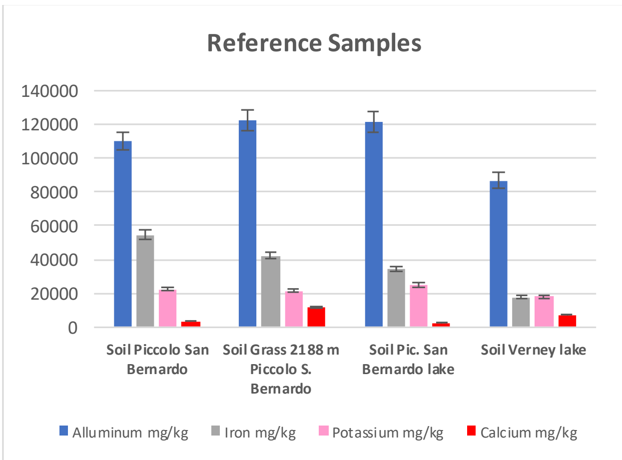

Fig. 9. Reference Samples Graph – Al, Fe, K, Ca.

IV. CONCLUSIONS

In conclusion it can noted that:

- Aluminum is present as clays formed by the degrading of aluminosilicate-based rocks. Clays are in the excavation, outer points, and reference samples. Soil coloration depends on iron presence (natural and anthropogenic), which gives it a reddish color. If manganese is present, soil coloration tends to gray or black. Manganese is present in slag from iron production, where this element accumulates.
- Calcium differentiates the different areas of the site used for permanent or seasonal habitation. Seasonal sites pavements were predominantly dry-stone (Roman period or Savoy defensive line), while in the medieval period, lime mortar is used for paving, reinforcing masonry, and plastering [5].
- 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.
- Phosphorus and sulfur fairly follow what has been said for potassium and sodium, 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 above, they can be derived from iron processing activity [6].
- Copper is present in all the excavation areas, as well as in outer samples and small amounts in the reference samples. Copper as a natural rock element is poorly soluble, in the excavation areas easily soluble copper is denoted the use for tools or vessels manufacture. Its presence in some outer areas can be attributed to its use as a phytopharmaceutical agent.
- Lead is present in the shallowest layers in excavation areas A, C and G. It is also found outside and in high amounts in Outside soil grass West sample perhaps a trace of the area's military past. The presence of lead in the reference samples is mainly due to anthropogenic origin and can be traced to vehicular traffic. It is found in a soluble and bioavailable form.
- Cadmium is present at trace levels and particularly in excavation area C US 3034 sample, along with cobalt, nickel, zinc chromium, and lead. This is where the highest concentrations of these elements are found, suggesting an area of metal processing.

Carbon is mainly found as inorganic carbon associated with calcium, particularly as calcium carbonate from the use of lime as in excavation area G. Another source of carbon is the carbonaceous residues from hearths as in excavation area C. High amounts of organic carbon are found in the outer samples and in the blanks due to the presence of plant residues. The lowest values are found in excavation area A.

V. HEADINGS

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