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Study of a Set of Structures of Surfaces Linked to a Developed Cavite in DR-Congo (Case of the Former Kasa-Vubu Cemetery)

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ABSTRACT: The use of geophysics for archaeological work, carried out on a rural settlement site of the former KASA -VUBU cemetery, defined by a set of artificial cavities and surface structures, goes beyond the objectives conventional detection of buried remains, additional information to the excavation, in particular as regards the description of the relationships of the local geology, the location of the site and the extension of the habitat area around the main access to the underground. This study made it possible to highlight the archaeological results as well as the electrical and magnetic anomalies in order to contribute to the analysis of the function of the pits.

KEYWORDS: Resistivity, Magnetic susceptibility, cavities, pits.

I. INTRODUCTION

As part of the excavation, an artificial cavity fitted out with a surface linked to the site of the former Kasa-Vubu cemetery (in the commune of Kasa-Vubu not far from the Kimbanguiste reception center) shown in Figure 1 , we carried out, a descent on the ground with the collaboration of the team of archaeological prospecting of the center of research in geophysics (CRG), a geophysical prospecting was carried out of which the double goal was to orient the excavation by detecting possible surface structures, rarely perceptible when surveying the ground in the undergrowth, and trying to understand the limits of the extension of the site around an artificial cavity created by man. Indeed, several recent construction works have highlighted cavity - surface structure relationships at this site, which extends over 2.55 hectares of empty land and which has been undergoing transformations for some time. Masons lay foundations, walls rise and large vehicles throw rubble a little further; this situation raises questions on the part of the population on its subdivision, because the concession of the former kasa-vubu cemetery has for decades been the subject of repeated controversies on the one hand for the Congolese State and on the other hand for the family of the Humbu-Lingwala community. Surface stripping related to the plumb cavity has uncovered several circular and quadrangular ditches, several holes, wells, tombs at the end of the oval excavated structures.
The visual perspectives of sites now make it possible to subordinate the problem of underground ditches to a comprehensive study of the sites, considering underground structures as elements linked to the habitation of the colonial era.

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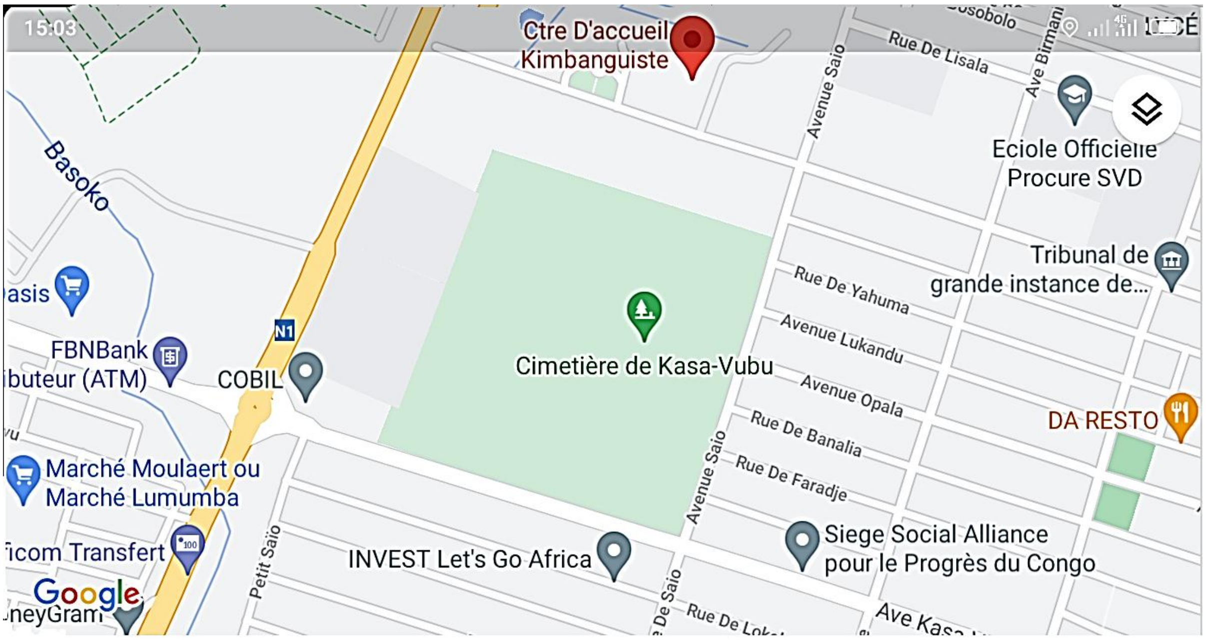

Figure 01: Plan of the concession of the ex-cemetery of KASA-VUBU

II. METHOD AND DATA

The choice of geophysical prospecting methods (electrical and electromagnetic) used on this site was made according to criteria linked to the knowledge acquired on the sites previously excavated, in particular the hollow structures (pits, hut bottom, etc.) filled with brown earth organic in a granite arena background. Two major physical properties of soils could make it possible to distinguish these fillings from the natural context are resistivity (depending essentially on texture) and magnetic susceptibility (depending on iron oxides in the soil). [3]

These two types of geophysical prospecting methods were therefore carried out before excavation as follows:

1) An electrical prospecting with a 2 m2 mesh with a wennerquadrupole in line and a spacing of two meters between the electrodes;
2) Electromagnetic prospecting with the sounding device (SH3), given the high resistivity of the land (around 2,000 Ωm). Only the variations of the apparent magnetic susceptibility of the ground could be measured, the prospected surface is approximately 25,500 m^2.

The anomalies detected, both in apparent resistivity and in apparent magnetic susceptibility, although individualized, could not be interpreted before excavation in terms of archaeological structures. The establishment of the surface excavation sectors was carried out, on the one hand according to archaeological criteria: surface-cavity relationship, areas of collapse, etc.) And on the other hand, according to surveys established at the boundary high susceptibility abnormalities. [1]

The data used in this present work highlighted the geological and archaeological aspect of this site:

1) **On the geological aspect:**

They take into account the arena area of the former kasa-vubu cemetery with an alteration vein (clay-sandy silt).

2) **On the archaeological aspect:**

The points (A, B, C, D, E) described in Fig.2, constitute hemispherical pits having diameters of 1.30 to 1.80 m; with a depth of up to 3 m. These layers or areas have the following characteristics:

1. Layer of the prospected area (D): pear-shaped silo belonging to a set of three intersecting pits with a diameter of 1.20 m to a depth of 1.40 m.
2) Prospected Zone (E): original, gently sloping access to the cavity, maximum depth to the west: 2.30 m.
3) Prospected area (F): in the form of a hemispherical shaped room, originally underground. The collapse of the vault during the occupation period linked this structure to the surface.

The general stratigraphy of the site shows that under the humus we successively find a layer of earth fill, fossilizing all the structures and filling the access to the cavity. Its upper limit is understood with the infra humus layer of the zone as well as a compact homogeneous and mineral layer of ocher-red color (layer H). Its power varies from 0.10 m to 0.50 m. It covers the granite substrate and the weathering vein. Finally, in the lower position, there is the internal filling of the pits. [2]

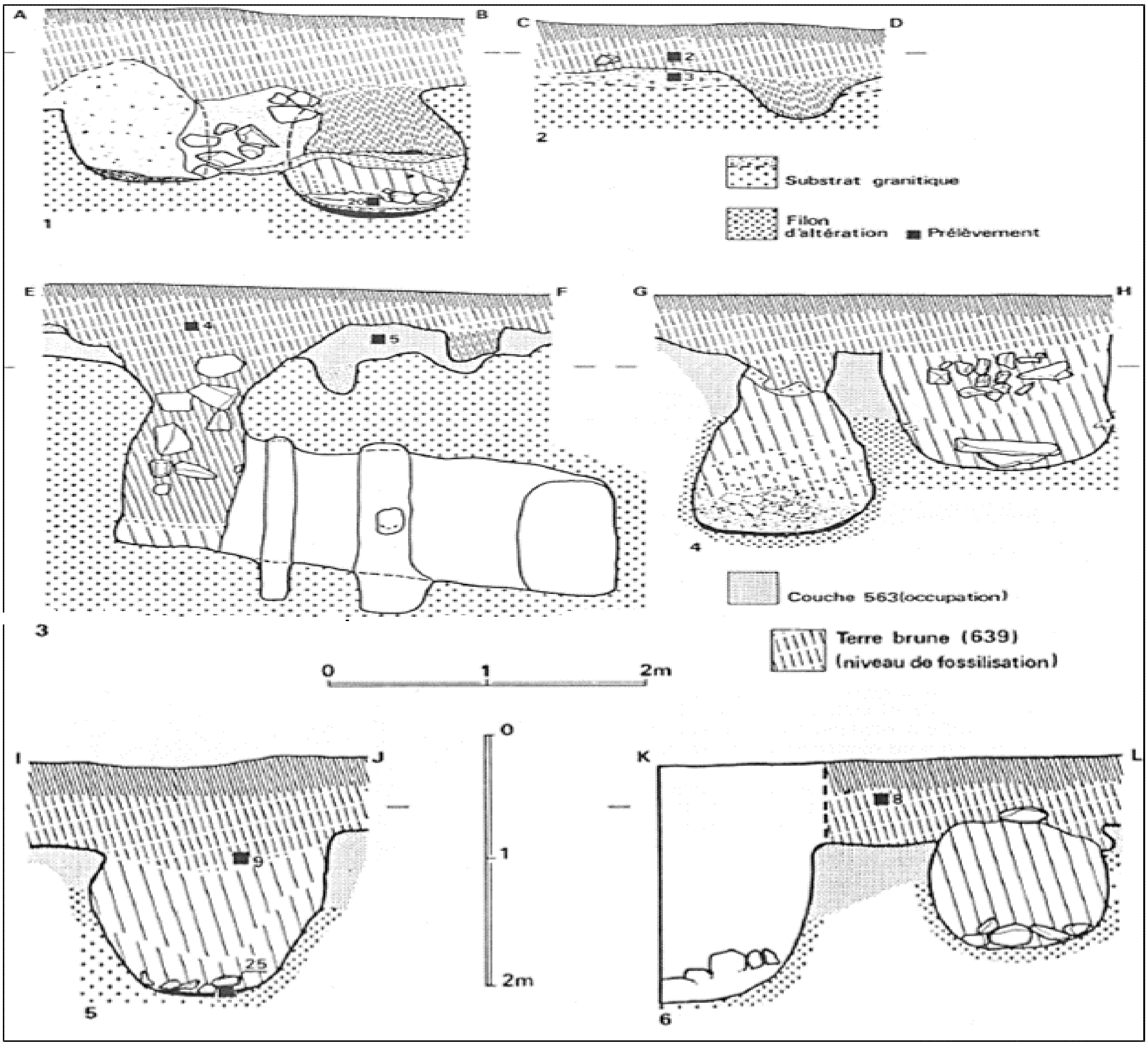

Fig.2: Planche Stratigraphique et situation des prélèvements

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In addition, the partial plan of the archaeological structures, location of the samples taken is represented by the Figure opposite:

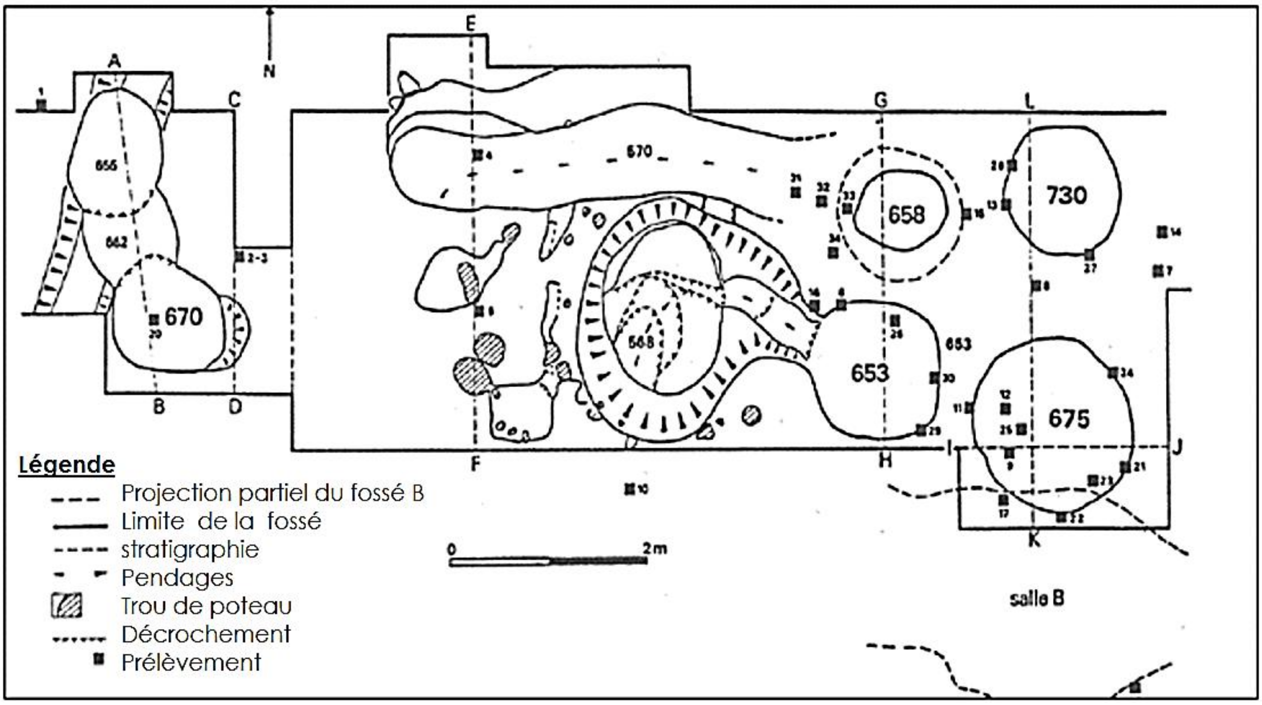

Fig. 3: partial plan of the archaeological structures

III. RESULT AND INTERPRETATION

The internal stratigraphic analysis of the pits shown in Fig. 2, made it possible to distinguish several types of filling testifying to different archaeological facts:

- A layer of paleo-seeds discovered at the bottom of the area (D) reveals the primary use of this area as a grain storage structure;
- The layers rich in furniture, differentiated and few in number, found only in zone D, denote a use of the pit (after abandoning the storage function) as a domestic dumping ground;
- In the pit (G), the stones organized with a packed mineral sediment form a wall reconstituting the north wall of zone D. Voluntary filling corresponds to a construction.
- In the prospected pits (H, A, B, C) we note layers of homogeneous brown earth or mixed with clay, very poor in archaeological material, with the presence of stone clusters in the lower part of these structures. These fillings where only a few layers can be distinguished, corresponding to the total occlusion of these pits, therefore to the final phase of their use.

We can therefore, with only stratigraphic analysis, prejudging their original function, the presence of clusters of stones on the bottom of certain pits cannot be linked to the final occlusion phase of the structures. Indeed, these appear in the form of piles which do not interfere with the upper layers (cfr. Pit B), where two large stones rest on the bottom of the structure, and the pits A and C, or piles of stones at their base are fossilized by levels of brown earth). These stones correspond to a voluntary filling of the graves. In addition to the analysis of the internal stratigraphy of the pits,the study of their morphology can provide additional information, while remaining cautious.

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In this regard, two observations should be noted:

- Pit D, pear-shaped, by virtue of its morphology, evokes a silo. However, the layer of paleo seeds discovered at the bottom of it seems to attest to its use as a storage structure. In this case, therefore, there is agreement between the study of morphology and the analysis of the fillings;
- The shape of the pit (H) also evokes a silo. But the internal stratigraphy does not allow this hypothesis to be confirmed and it seems hazardous to give a precise function to this type of structure by analyzing only its morphology. The study carried out following the geophysical prospecting, which consisted in measuring the magnetic susceptibility of the materials encountered during the excavation, made it possible to refine and complete the archaeological analysis and to provide new interpretable data.

The apparent resistivity mapping described in Fig. 4 yielded very high values (greater than 1800 Ωm), linked to the shallow depth of the granite substrate and its low degree of alteration.

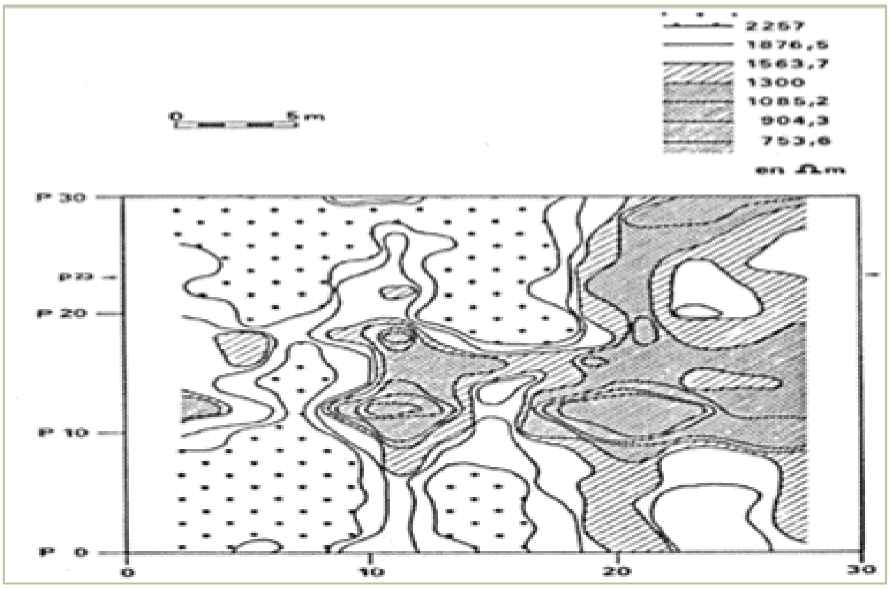

Fig. 4: Apparent Resistivity Map

However, we note the presence of several anomalies of low resistivity (□ less than 1500 Ωm), elongated, north-south direction. In its eastern part, the excavation intersected one of them transversely: We were able to highlight in this sector, and in the zone (F) of the cavity, a vein of alteration of leucogranite (argilo- silt). sandy) made up of materials that are finer and more porous than the neighboring rock (see Fig. 7) where the limits of the clay vein and the iso resistivity curves are jointly represented: 1300 Ωm.It therefore seems that Fig. 4 gave a plan of the zones of alteration of the leucogranite, being able to notice that the archaeological structures were developed indifferently in the latter and in the vein. The different lithological types do not seem to have constituted an insurmountable constraint, nor a factor favorable to the establishment of the structures. It illustrates the electrical prospecting with a 2 m2 mesh with a wennerquadrupole in line and a spacing of two meters between the electrodes.

We can see that the measurement of the apparent resistivity could not highlight the plan of the underground network and this for two main reasons:

[1] The conducted anomaly created by the granite alteration vein hides other weaker anomalies related to the presence of vacuum;

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[2] The low degree of alteration of the granite on the site, and the good state of conservation of the walls of the cavity, did not cause the phenomenon of preferential alteration of the rock directly above the underground vaults (Fig. 5).

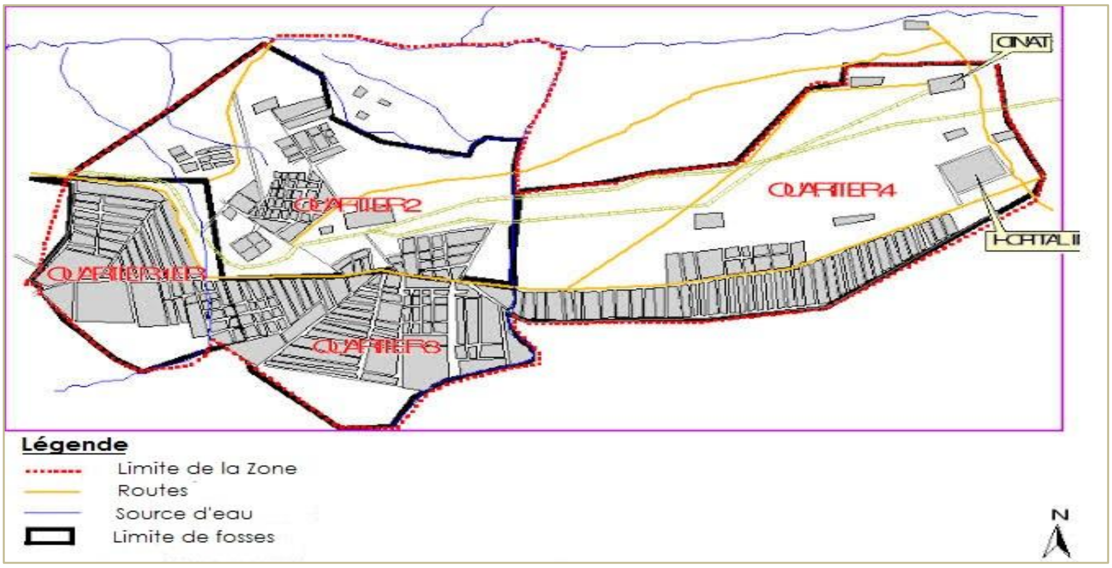

Fig. 5: The morphology of the prospected area

The description of layer models looks like this:

1st Layer:

e = 0.4 x = 25.10-5 USI □ = 1000 m

It corresponds to the humus and the upper part of the brown earth infill layer (**I**).

2nd Layer:

e = 0.25 m x = 45.10-5 USI □ = 500 m width = 2m, Length = 2 m.

It corresponds to the basis of layer **I** and **H** (occupation layers)

3rd Layer:

e = ∞ (infinite) x = 15.10-5 USI □ = 1500 m

It corresponds to the granite substrate.

These different layers are described in Fig. 6 opposite:

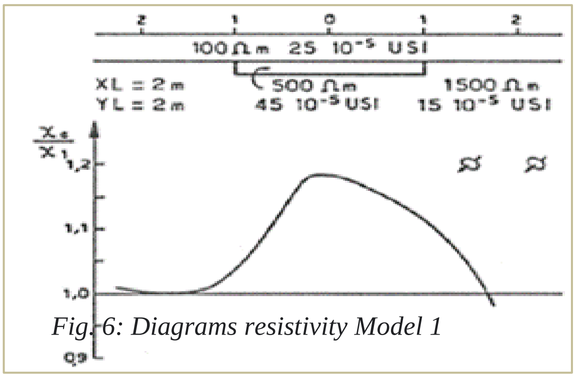

Fig. 6: Diagrams resistivity Model 1

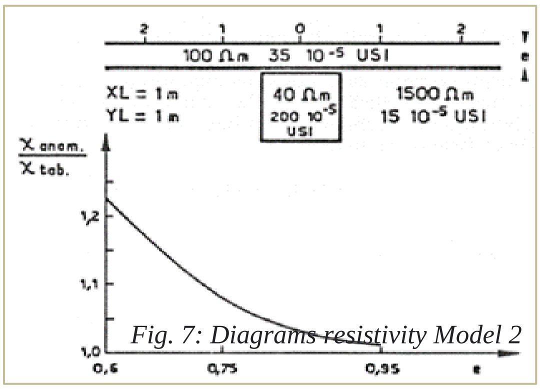

Fig. 7: Diagrams resistivity Model 2

We observe an increase in apparent magnetic susceptibility above this structure of about 18% (25.10-5 USI in tabular response without the thin film, 30.10-5 USI with the thin film). The anomaly mapped using the SH3 device corresponds to an increase of about 15% (taking the iso values 55.9 and 64.6.10-5 USI curves). We therefore observe

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good consistency, in terms of relative anomaly between the two results. In view of all these arguments, we can therefore estimate that the electromagnetic prospecting allowed the mapping of the layers of voluntary backfill and occupation and therefore to give their lateral extension on the site. In fact, we note the concordance of these phenomena with the relatively large number and archaeological evidence in the immediate vicinity, or as an extension of the permanent access to the developed cavity, a phenomenon observed on other sites.

As part of this sampling campaign, the magnetic susceptibility of several samples of the clay vein was measured. Of the 19 samples measured, 9 gave comparable mean values of 21.25.10-5 USI (samples # 18, 21 to 24, 24, 26 to 28, 34), which appear to correspond to the values of the natural magnetic susceptibility of this type of materials on the site. The dispersion of the measurements and the very high value of sample No. 06 (177.10-5 USI) prompted us to complete the sampling of this type of material from the walls of zone B and from the pits dug in the vein.

The 4 samples taken from the walls of pit 653 gave very strong values: 177.0, 201.0, 80.4 and 155.8 10-5 USI (samples n ° 6, 16, 29 and 30). The sample taken from pit 658 gave a high value: 76.4.10-5 ICU (sample No. 15). Finally, several samples gave intermediate values between 20.6 and 55.10-5 USI (Cfr Fig. 7).

These different values are represented using the table opposite:

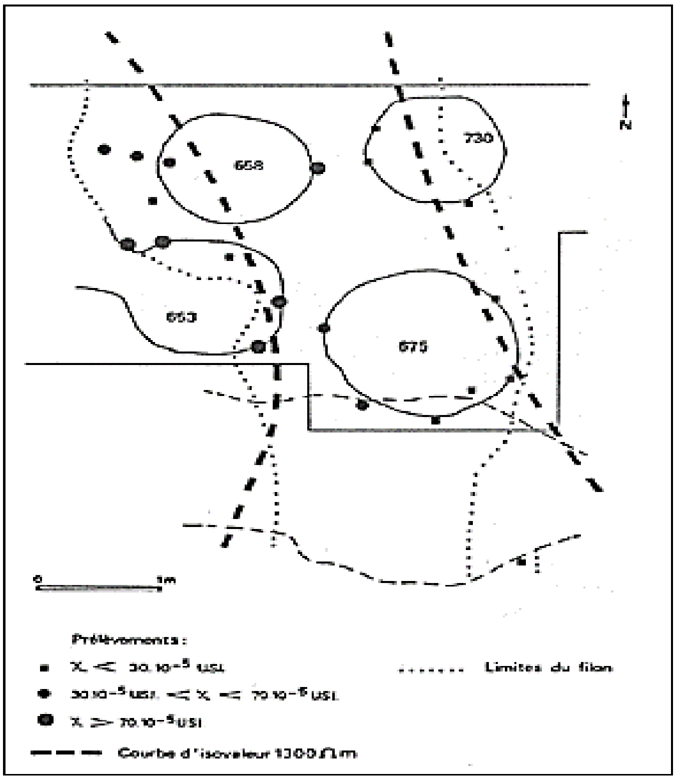

Fig. 8: Magnetic susceptibility map of the samples

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Table I.: Magnetic susceptibility sampling of different samples

N° Sampling	N° sector	layer/Area prospected	Layer Designation/ Prospected Area	Magnetic susceptibility
01	7	G	Couche de remblai zone des fosses	42,6
02	7	G	-	38,4
03	7	Substrat	(Altéré) en surface	20,1
04	3	I	couche de comblement de l'accès souterrain (Abandon)	42,7
05	3	H	Couche surface occupation	37,8
06	3	B	Argile rouge paroi Nord du fossé	177,8
07	11	H	Couche surface occupation	35,2
08	11	J	Couche d'occlusion fosse A	35,2
09	11	J	Couche d'occlusion fosse C	34,2
10	-	Humus	Humus de référence	32,6
11	11	C	Argile Paroi ouest	53,3
12	11	K	Couche Argile blanche au fond du fossé C	19,1
13	11	A	Paroi Ouest fosse A	25,1
14	11	H	Couche surface (occupation)	40,6
15	3	B	Argile rouge paroi Est du fossé	46,4
16	3	Argile	Entre les fosses B et H	201,1
17	2	Argile	Paroi Nord de la fosse	43,2
18	2	Argile	Paroi Sud-Est	26,64
19	2	Substrat	Paroi Galerie	13,6
20	7	L	Paroi Sud-Est de la fosse C	29,7
21	11	C	Paroi Sud fosse C	22,31
22	11	C	Fond Nord-Est fosse C	20,2
23	11	C	Fond fosse C	20,1
24	11	C	Fond Nord-Est fosse C	20,5
25	11	K	Argile Blanche fond fosse C	20,4
26	11	A	Argile Paroi Nord-Ouest	20,6
27	11	A	Argile Paroi Sud fosse A	20,5
28	3	B	Argile Paroi Nord fosse B	20,4
29	3	B	Argile Paroi Sud Fosse B	80,4
30	3	B	Argile Paroi Est fosse B	155,8
31	3	Argile	Entre l'accès cavité et fosse A	30,45
32	3	Argile	-	50,25
33	3	Argile	-	40,6
34	3	Argile	Sud-Ouest Fosse A	20,5

The figure. 07 shows a maximum zone (values greater than 64.6.10-5 USI) elongated in a south-easterly direction. The excavation carried out on this anomaly revealed a relatively large number of archaeological structures (pits, silos, collapsed area) with brown earth fillings (voluntary backfill). In this zone, the H layer (ocher-red mineral) is inserted between the embankments and the parent rock and / or the alteration vein (gives figure 3).

Such characters are not found in surveys implanted in areas of low susceptibility. The fillings consisted of loose alteritic "gravel".

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We can deduce that there is a correlation between the presence of the H layer, the infills of the discovered structures and the anomalies of higher susceptibility. This observation prompted us to measure as systematically as possible the magnetic susceptibility of the layers encountered in stratigraphy as described in Fig. 3 Plate 1, samples 1 to 35, 17 and 19.

Humus, measured several times, gives constant values around 30.10-5 USI (sample # 10).

The layer of brown earth, corresponds to a voluntary backfilling of structures, has greater susceptibilities, around 35 to 42.10-5 ICU. Most of the samples of this layer were taken from 30 to 40 cm from the surface, due to the fact that at this depth, it is well individualized while in its upper part, it gradually passes to the humus without it. it is possible to distinguish clear limits (samples n ° 1, 2, 4,8 and 9). Layer (G) taken three times also gives values greater than those of humus: between 35 and 40.10-5 USI (samples no. 5, 7 and 14). The measurement of the susceptibility of the granite was carried out at two distinct places on the one hand in its upper part where it is arenized, its value corresponds to 20.10-5 USI (sample n ° 3), and on the other hand at the interior of the underground where the rock is coherent, with a value of 13.10-5 USI (sample n ° 19).

We found the following:

- First, we see that there is an absolute difference in value between the measurements of the survey and those of the sample. This stems from a sampling problem with the SH3 device, and the fact that the measurements taken from the sample are made per unit mass and that the density of the samples is not exactly known.
- Second, in view of these results, it would seem that the base of layer (I) (brown earth) and layer (H) are responsible for the anomaly visible in mapping.

Their levels have a higher susceptibility than humus and are not found in areas excavated outside the anomaly. In order to validate this hypothesis, we calculated the theoretical anomaly created by a thin layer of susceptibility higher than that of the upper humus, to find out whether the calculated anomaly is that measured in prospecting. [7]

We first notice that, despite the high magnetic susceptibility values of the alteration vein on the walls of pit B, there are hardly any particular anomalies in line with this pit. [4]

The explanation lies both in the depth at which the vein is located and in the fact that only the wall of the pit has lower values. We place ourselves in a maximum hypothesis where the pit would be entirely filled with a material of high susceptibility, no longer giving any detectable anomaly: it is located below the 10% threshold beyond which it is estimated that an anomaly is difficult to identify. As such (The response is expressed as the ratio between the apparent magnetic susceptibility at the maximum of the anomaly plumb with the structure, and the apparent magnetic susceptibility of the tabular response without the structure).

In the second place, the strong values concentrated on the edges of the pit B would seem to testify to a particular use of this one. Indeed, in archeology the form and the filling (secondary filling) do not allow to advance serious hypotheses on its primary use. We also note that the clay vein has no macroscopic particularity observable in this pit (traces of smoothing, apparent reddening, ...). One of the plausible explanations for such an increase in susceptibility (10 times the normal value) could be a significant heating of the material which constitutes the walls of the pit: when a soil or a rock undergoes a noticeable rise in temperature, the weakly magnetic iron oxide Fe_2O_3 (hematite) is reduced in the form of a very magnetic oxide: Fe_3O_4 (magnetite) which can reoxidize to Fe_2O_3 (magnetite) also magnetic, or cannot reoxidize if the medium is depleted in oxygen due to the filling of the pit. If we admit that there was an increase in temperature in this pit, as suggested by the susceptibility values, the absence of any trace of reddening on the clay wall of the structure, and the normal value of a sample taken at the bottom of the pit in the same material (sample n ° 28: 20,4.10-5 ICU) suggest that there would have been an internal lining of the pit during the heating episodes. The presence on the site, at the base and within the fillings, of numerous stones having undergone significant heating on one of their faces, could correspond to the remains of a primary organization of the B pit, seat of an activity requiring a heat supply (crafts).The sample taken from the east wall of the L-pit also has a high magnetic susceptibility: 76.4.10-5 U.S.I. (sample n ° 15). This silo-shaped pit evokes by its morphology a structure with a storage function. The remarkable increase in the susceptibility of the material of the walls of the pit could correspond to a mechanism of reduction of the oxides linked to the fermentation of organic matter in an anaerobic environment. This assumption would be consistent

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with a "storage" function (cereals, ...). A detailed study of the macroscopic traces of the fillings and walls would provide new data useful for the analysis of this pit, the only morphological analogy with silos already excavated being largely insufficient for the understanding of the archaeological phenomena linked to the initial function of this type. of structures. [5]

IV. ACKNOWLEDGMENTS

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V. CONCLUSION

Beyond one of the classic objectives of the geophysical prospecting carried out, a surface structure linked to a developed cavity, on a habitat site of the ex-cemetery of KASA-VUBU, consisting in detecting buried remains (pits , tomb, foundation of walls, ...), this work has shown its important contribution to the understanding of the environment of an archaeological site and its extension. The archaeological analysis and measurements of some physical properties of the soils allowed a more in-depth interpretation of the initial data from the geophysical prospecting:

- On the geological level: situate the archaeological structures in their natural context, and show that the excavation of the cavity and the surface structures apparently took place without prior knowledge of the subsoil;
- On the archaeological level: locate the layers of abandonment and occupation and therefore provide the probable extension of the habitat zone located in the immediate vicinity and in the extension of the permanent access to the cavity.

Finally, the site of the ex-cemetery of KASA-VUBU from an archaeological point of view presents multifaceted structures in a context of medieval pits, allowing this structure to be attributed probably as a food reserve and domestic dumping ground. The study of the magnetic susceptibility values following geophysical surveys generally shows that the Stratigraphy of the site under the humus has a layer of earth fill.

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