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The informative contribution of the geophysics in the preventive archeology for the knowledge, the protection and planning of restoration project: the case of the Grange of Ventrile.

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Abstract – Nowadays the use of the geophysical introspections has entered completely in the methodologies of archaeological inquiries, aimed not only to the discovery or to the spatial definition of possible buried archaeological evidences, but also in the description of a possible state of conservation. The utilization of these non-invasive investigations, perpetrated also in the Italian legislation about the preventive archaeology, permits so to know better the investigated asset and the contiguous territory. These informations help to plan better all the activities concerning the protection interventions and the restoration of real estate and the territorial planning. This contribute illustrates the data of a particular type of intervention, where to the process of planning action aiming to the protection and to improvement of possible buried archeological evidences, under a structure that is already a real estate (Grange of Ventrile), has been added a wider cognitive project for a territorial planning.

Keywords: – Non-destructive techniques, architectural heritage, diagnostics, geophysical methods, GPR, ERT, preventive archeology

I. INTRODUCTION

Thanks to the contribution of researchers and professionals in the last decades we have assisted to a consisting evolution of methods and of non-destructive archaeological techniques. This development of the technology, of the instrumentation, in the acquisition and in the restitution of the data, has favoured their employment in a multitude of context, permitting an increasing multidisciplinarity united to the continuous research of the knowledge and of the precision. In fact they are used, at diagnostic level, in the archaeological field for the individuation or the plano-volumetric definition of anomalies related to burial archaeological evidences, or inside to buildings for the location of empty or space or anyway with different conformation or also in the restoration work for defining the conservation state of the real estate (degradation or damages). These versatile methods, fast and precise in the pseudo-geometrical resolution are suitable to complex and stratified contexts, typical of the archaeological or restoration field. Today these techniques don’t constitute only an opportunity for research disciplines but a real necessity linked to the increasing lack of fundings.

II. DIAGNOSTIC ANALYSIS ON ARCHITECTURAL HERITAGE

The results proposed in this contribution are the fruits of a series of cognitive investigation of a very particular cultural context, such as that of Grange of Ventrile in Agro of Chiaromonte (PZ). This structure during the last two years, thanks to an European project, is object of a series of intervention directed to the recovery, restoration and valorization of the monumental complex. In order to implement the cognitive framework of the same in conformity with the legislative regulation and the prescriptions of the Archaeological and Architectonic-Landscape Superintendence of Basilicata, have been realized a series of non-invasive investigations. The methodology applied are GPR and ERT that have integrated the data gathered thanks to geognostic and thermographic investigations previously realized. Both the techniques, defined active, have the aim to give information about the architectonic characteristics of the cultural estate about the principal stratigraphic relations of subsoil (alluvial steps). The planimetric and altimetric development of the architectonic complex is not much known, because of the lack of graphic historical attestations and especially because of its almost complete

obliteration under a series of alluvial warps. The choice of the investigation methodologies to use is tied to the intrinsic characteristics of the context: a stone structure (*target*) covered by fluvial warps of different hierarchic order (*median*), a reasonable presence of water [1]. The diagnostics context and its physical-chemical peculiarities cover an important role for the survey of discontinuities due to anthropic or natural actions. Both the techniques permit to illustrate, at different depths and levels of resolution, the anomalies connected to the target, through two-three-dimensional restitutions. In particular ERT measures the variations of the electrical resistivity, while GPR measures the values of dielectric permittivity.
The cognitive campaign has foreseen the realization of 77 GPR profiles, parallel, equidistant (0,50 m.) and distributed or on the inside (areas A, B, C, and D) or outside of the structure (areas E, F), in total 600 m. and 3 geoelectrical tomographies, of which two are 63 m. and one is 28 m. (Fig. 1). The different length of GPR profiles is due to the presence of obstacles (accumulation of heap of stones).

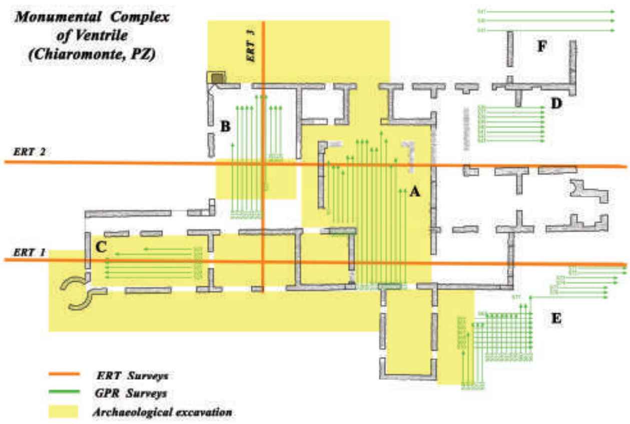


Fig. 1: Planimetric representation of the investigations in the examined context.

The georadar investigations have allowed to analyze a medium depth of about 2 meters, while the geoelectrical has permitted the characterization of a ground until to 10-15 meters of depth for the surface area. It has been very interesting to notice the answer registered by the instruments in a structurally confused context from the point of view of structure (fluvial warps) but clear in its conformation (great difference between target and means, visible especially with the geoelectrics - *Fig. 2*).
Therefore it has been discriminating the knowledge of the materials used for the realization of the complex, of the distributive character of the possible collapse and the surrounding environmental context.

III. ARCHAEOLOGICAL FRAMEWORK

The investigated area is strategically favorable to the human presence, permitting to control the valleys of the Sinni and Agri rivers, that have always constituted the principal streets of penetration that from the ionic coast lead to the hinterland. During the medieval age this territory constituted an important political centre of the wide countship of Chiaromonte, dominion of Norman origin, whose possessions reached the northern part of Calabria. This barony promoted therefore the construction and the reconstruction of defensive structures but also of ecclesiastical buildings situated principally near the fluvial course. From the ecclesiastical point of view the territory was under the government of the Tursi-Anglona diocese, of byzantine foundation, Latinized with the Norman conquest of Basilicata between the first and the second half of the XI century [2].

Fig. 2. Placement of the Grange of Ventrile

In detail, the context interested by the investigations is that of the Grange of Ventrile ruins, one of the largest and flourishing accessories of the cistercian abbey of S. Mary of Sagittarius at Chiaromonte (PZ) [3]. The historical sources date back the foundation of benedictine-cistercian settlement at the confluence of the rivers Frida and Sinni, in 1061 for the devotion of a rich citizen of Chiaromonte [4]. The little and original church passed therefore to the benedectine possessions of Sagittarius, becoming in the 13th century a big centre of production, transformation and distribution of agricultural-pastoral products. Afterwards and until the 19th century other structures were added to the initial church and cloister, as described also in an inventory dated 1807. With the suppression of the Sagittarius abbey owing the Napoleonic edicts, also this accessory was abandoned and suffered numerous sacks and divisions in parcels. The definitive destruction and disappearance happened in consequence of a disastrous flood due to overflowing of the Frida torrent and Sinni river at end of the 19th century[5]. This river which flows more in the north, covered of debris all the ground floor of the architectonic complex. Nowadays it is possible to observe the powerful ruins of the imposing structure situated in Vaccuta district of Francavilla at Sinni common (PZ). The Ventrile complex consists of a fortified build (with two towers, one with a square plan and the other with a circular plan, referable to the defense from the French sacks in the XVI century) and which reflects the mixture between the Cistercian architecture and the traditional buildings ways of the territory. This is realized with a constructive technique at double faces with fluvial cobblestones in regular courses of stones just rough-hewed and brick refuses tied with mortar, with a thickness between 0,50-0,60 m.

IV. METHODOLOGY

The campaign of measures aimed to the characterization of the underground, from the acquisition phase to the data interpretation, has been influenced by three important elements: imperfect homogeneity of the planking level with numerous obstacles; heterogeneity of the stratigraphic levels; different degrees of humidity of the stratigraphic levels [6].

The utilized georadar system is the SIR-300 of GSSI (Geophysical Survey System Inc) with antenna of 400 MHz; this has been defined on the basis of the characteristics of the soil, of the nature and of the dimensions of the wall evidences potentially recognizable. Because of the presence of superficial obstacles and irregularities of the soil, it has been necessary the registration of the echoes by means of marker, without using the usual survey wheel. The acquired data have been therefore processed with the Reflexw software applying various filters.

At first, the traces connected to moments of movement absence of the antenna on the surface (trace removal) have been removed, then to their calculation and to their normalization through trace interpolation and trace increment. After assigning coordinates to the profiles, the processing was actualized on the radargram that illustrated better clear and defined hyperbola and then applied to all other (*move start time*, *background removal*, *bandpassbutterworth*, *substract-mean*, *time cut*). On the achieved data it has been possible, through hyperbola method, to analyze the average velocity (0,09 m/ns) and to define the controlled depth. This speed concerns only the first strata, since the investigated mean can't be considered as isotropic and homogeneous. After that the migration and the collapse of hyperbola have been realized on the basis of the maximum recorded value (*Kirchhoff migration*, summation width 40, velocity m/ns 0,6630). This processing has permitted to improve the imaging and to focus the reflectors.

The geoelectrical prospecting has been fulfilled through a multichannel system that has allowed the simultaneous acquisitions, with ABEM 4000 SAS at 64 channels, therefore using 63 stakes arranged on an axis every metre which have crossed the investigated building in transversal and longitudinal way. In order to highlight better the horizontal structures of the subsoil the Wenner technique has been used.

This has permitted to define and to illustrate the presence of a structural discontinuities and to limit the geometries of the buried builds, through a pseudo-section of apparent resistivity.

The inversion and optimization processes of the recorded values have been executed by means of the ZondRes2D software. It is a computer program for 2.5D interpretation of electrical resistivity tomography. The first step was to prepare the data for the inversion, such as poor data detection. The next step was to select the inversion type and parameters. In order to transform the apparent resistivity pseudosection into a model representing the distribution of calculated electrical resistivity in the subsurface, we used the smoothness constrained that is an inversion by least-square method with use of smoothing operator.

V. RESULTS

A. GPR profiles [7]

For the data interpretation, the radagram have been analyzed at first in a rough format and then processed, at the aim to evaluate the filtering action.

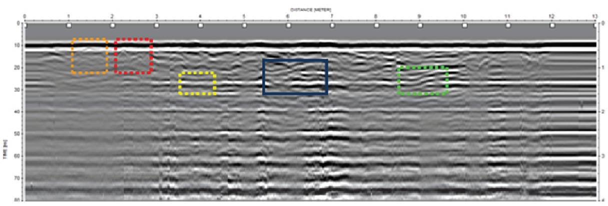
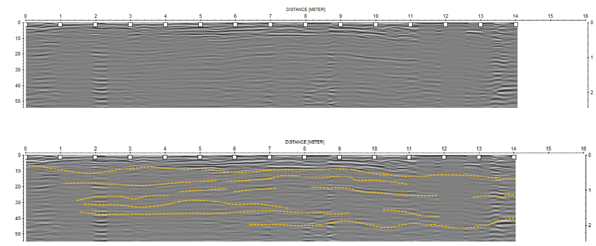


Fig. 3. This picture (radargram 46) shows the main radar signatures identified in the examined radargrams (red= hyperbolic; yellow=continuous; green=wavy; blu= dipping; orange= caothic).

In this document only some processed data are illustrated, that reflect better the checked situation in a similar way on the investigate area.



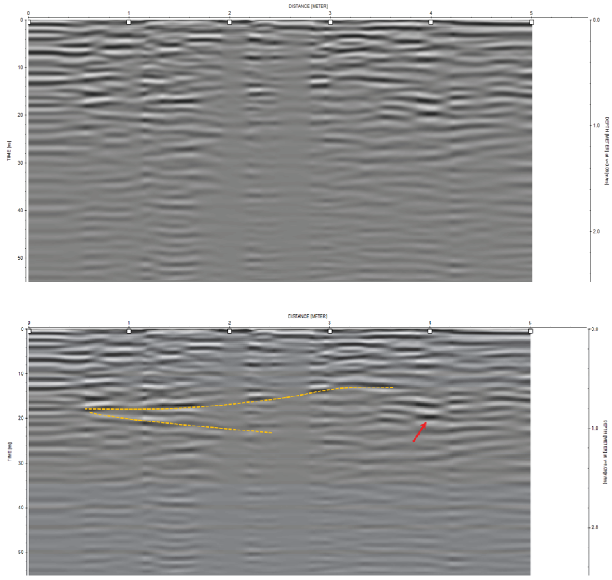


Fig. 4. The figure show 2 radargrams, accomplished with a 400 MHz antenna, migrated and topographically corrected: (a & b) GPR profile gpr10 long 14 m, (c &d) gpr73 long -5 m.

By proceeding from the top to down the several radargram seem to describe us some very alike sequences. As it is possible to observe in the *Fig. 4*, the first level of both the radagrams (about 0,40 m.) is characterized in the orthogonal direction to the acquisition by signatures chaotic and discontinuous, due to the presence of a very heterogeneous subsoil (cobblestone-flood and collapses level). Under these, in some points the presence of clear and marked hyperbola, indicated with a red arrow, related to possible wall structures, individuated in some profiles realized in the areas A, B, D, E, F. A series of horizontal, homogeneous and regular reflections are characteristics elements that are linked to the interfaces between couples of strata which have different electromagnetic features, typical of a geological/pedological passage (orange line in *Fig. 4*). In many sections some inclined plans are visible, that permit us to define the several phases of flood, sediment and collapse. At the depth of about 2 m. from the planking level the lost of signal happens, due to the degree of saturation of the water that together to the chemical properties, influence the dielectric and conductive characteristics of the materials. At this depth, as appeared previously from geognostic surveys and then from the stratigraphic data, it has been noticed the emersion of the water table and the presence of a very conductive clayey strata that have dispersed the introduced energy. This element is showed as a continuous horizontal reflector running along the all profiles at 2 m. of depth. The stratigraphic sequence individuated in the superficial strata by radragrams has been later confirmed by the stratigraphy emerged with geognostic surveys and with archaeological excavations.

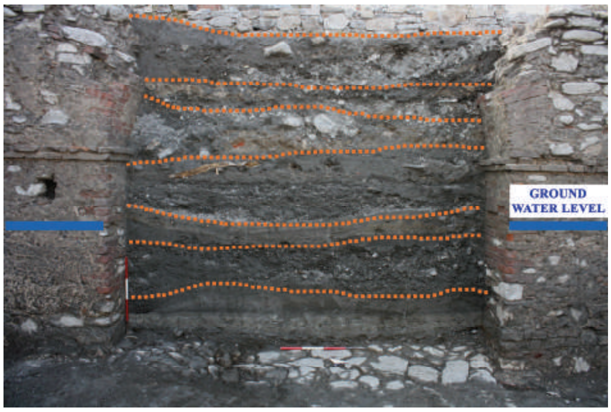


Fig. 5. Archeological stratigraphy in area A

B. ERT profiles

The figure 6 shows the results of the three electrical resistivity tomographies (ERT). The data are defined by a resistivity range between 30 to 1500 Ohm*m. The ERT images highlight two main electrical layers: a shallow relative high resistivity layer (>300Ohm*m) and a deep relative conductive zone (<100Ohm*m). The resistivity layers are connected to the conformation that divides in a clear way the architectural structure from the alluvial strata (sand, gravel and clay).

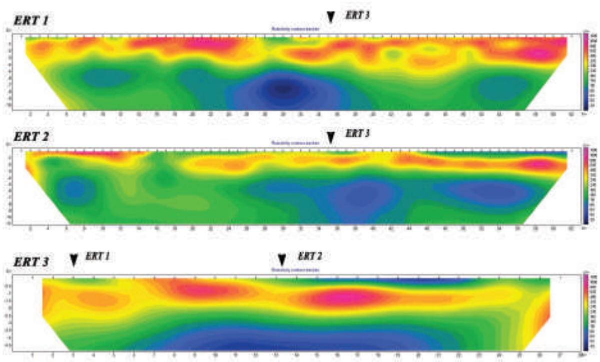


Fig. 6. ERT profiles (a) T1-63m, (b) T2-63m and (c) T3-28 m show the inversion models whose interpretations are based on resistivity values and borehole data. The distances and depths are in meters.

By integrating the ERT data it has been observed a precise distinction between the anthropic plan, defined by relative high values of resistivity from the surface to 4m. This discriminating limit would sign in a drastic way a caesura between two different corps: the first one of the architectural complex and the second one of the geologic.

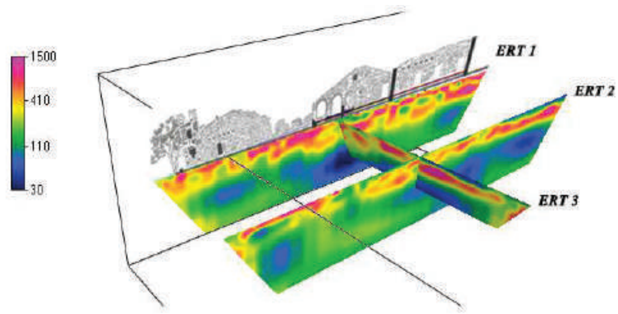


Fig. 7. ERT pseudo 3D visualization

In order to interpret better the data, they have been compared with the existing planimetry at the moment of acquisition. It has been noted that in different zones of the tomography there is a presence of more resistive bodies with sub vertical shapes, nearly to remark some clear vertical passages (walls or collapses). This type of anomaly has been identified both in the inside areas A and C, crossed by the ERT 1, and in the areas A and B crossed by the ERT 2. So the same values of resistivity have been compared at first with the single levels of the stratigraphic columns of the surveys and afterwards confirmed or less by archaeological excavations. The granulometric features obtained with the surveys permit to establish a positive relation with the resistivity values, registered in the geophysical survey.

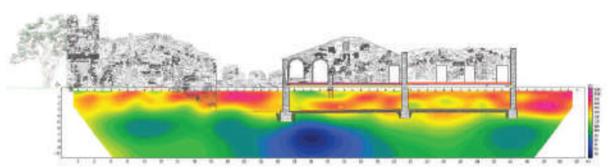


Fig. 8. comparison of the ERT 1 data with archaeological data

The lack of the continuity of the wall structure base, located at 3-4 m. from the surface area, has been defined as a floor breaking or as a different structural conformation of the archaeological plans.

VI. CONCLUSIONS

The integration of the data collected by means of the aid of GPR and ERT techniques has allowed to define better the articulation of the buried architectonic complex and the knowledge of structural and destructive events (collapses). These information, joined to the precise data offered by 7 boreholes drilled and confirmed largely during the phase of archaeological excavations, have given an important cognitive framework, utilized by Superintendence and by the contracting body of the works for the definition of the program and of the intervention.

In this way it has been possible to draw up in a reliable way a plan of research detailed in costs, times and working units.

The informative table has defined the plano-volumetric development of the alluvial deposits, through a complete sedimentological and lithological characterization of the subsoil. In fact 7 fundamental stratigraphic units are recognized, distinctive in different archaeological “moments.”

At the same time it has been possible to mark the potentialities and the limits of these methods in an alluvial context and poor of water in surface. While the GPR data have given a detailed imagine of the most superficial strata of subsoil, investigating less in depth, but rich in particulars; the ERT data have allowed to characterize with a minor geometrical meticulousness at higher depth.

In conclusion it is necessary to underline how the contribution of these non invasive, cheap and fast investigations, can notably facilitate the research work and the intervention planning, not only in favour of public research but also for the realization of extensive projects.

VII. ACKNOWLEDGE

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