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Tanasi[1] D., Hassam[1] S., Trapani[2] P., Cali[1] D., De Giorgi[3] L., Ferrari[3] I., Giuri[3] G., Leucci[3] G.

1) University of South Florida, Institute for Digital Exploration (IDEx), Department of History
2) University of Catania
3) Consiglio Nazionale delle Ricerche, Istituto di Scienze del Patrimonio Culturale
*) corresponding author, giovanni.leucci@cnr.it

Abstract. The Villa of Caddeddi, in the territory of Noto (Siracusa) is located on the south bank of the Tellaro river, about 3km from its mouth. The site, interpreted as a rural luxury residence dated to the 4th-5th century CE, was first discovered in 1972 and intermittently investigated in the subsequent decades and mostly studied from the perspectives of the splendid mosaic floors there uncovered. The excavated structure accounts for just a portion of the complex, which is partially covered by an 18th-19th century farmhouse. After a long period of neglect, the villa has been recently restored and opened to the public and become subject of new studies by the University of South Florida's Institute for Digital Exploration (IDEx) which in 2019 and 2020 conducted a remote sensing campaign entailing terrestrial laserscanning and ground penetrating radar.

1. Introduction

The large Late Roman villa of Caddeddi (also known as Vaddeddi), on the right bank of the Tellaro river in the municipality of Noto, was fortuitously discovered in the early 70s and systematically investigated in 1972 [1] with intermittent excavations through 2010 [2,3]. A portion of the site was reused as an Islamic cemetery in the medieval period [4] and later partly covered by the construction of a large farmhouse complex in the 18th and 19th century. The villa is organized on two floors around a central peristyle that is surrounded by living quarters. Only the north and south sides of the living quarters are preserved. The upper rooms were decorated with lavish floor mosaics that portray scenes of the redemption of the body of Hector, a hunting scene arranged around a seated female figure, perhaps the personification of Africa, and a Bacchic scene, all flanked to the south by a geometric mosaic in the corridor. The mosaics, dated to around the second half of the 4th century CE, are most immediately comparable with those of Piazza Armerina and villas of Africa Proconsularis; indeed, the mosaics are likely the work of African mosaicists [5].

Figure 1. The archaeological site of the Villa of Caddeddi

After a long hiatus in fieldwork on the site, in 2019 the Institute for Digital Exploration – IDEx (www.usfidex.com) of the University of South Florida launched a campaign of digital prospections entailing the overall laser scanning of the complex and a survey via ground penetrating radar of the unexcavated area falling within the borders of the archaeological park. In particular, the GPR survey was undertaken with the intent to shed light on those parts of the villa that are still covered and the eventual presence of further unexcavated Islamic burials.
Specifically, this paper reports the results of the ground penetrating radar (GPR) survey conducted in September 2020 in some unexcavated areas of the site. The acquisition was performed along a series of closely spaced lines and the processed data were visualized as two-dimensional vertical sections (GPR), depth slices, or three-dimensional volumes (GPR), to allow an integrated interpretation of the geophysical results. The analysis of the geophysical data sets revealed a series of anomalies related to possible archaeological structures.
The non-invasive nature of geophysical surveys makes their use an increasingly vital complement to invasive archaeological investigations. Among them, ground penetrating radar (GPR) plays a special role because it can provide subsurface information with a resolution far greater than that obtained by other geophysical methods, provided it is done in favorable conditions, i.e., resistive nonmagnetic environments [6,7]. After appropriate data processing, various three-dimensional visualization techniques are currently used to display the GPR data in a convenient way for understanding the spatial relationships between the anomalous zones and improving their archaeological interpretation. Time-slice (or depth-slice) maps is the most popular GPR visualization method [6,7,8], since it provides a comprehensive plan view of the anomaly patterns at various depths, making it easier to correlate with structures in increasingly deeper archaeological units. However, in complex environments the interpretation of time slices can be misleading as false amplitude anomalies can occur when the slicing planes intersect dipping or undulating reflectors [6]. In these cases, other three-dimensional data presentations, including three-dimensional cubes and slices parallel to the axes or along arbitrary directions, can be more suitable [7]. For large areas, geophysical methods have been used in combination with other complementary technologies, such as interpretation of aerial photography and/or satellite imagery, global positioning systems (GPS) and laser scanning data [7,8].

2. GPR survey

The GPR investigations were carried out within five areas (Fig. 2). GPR data were acquired using the Ris Hi-mod system equipped with a dual band antenna 200-600MHz. A 0.25 m grid, with 512 samples / track were used. The quality of the data was discreet thanks to a series of measures adopted in the acquisition phase. However, to eliminate noise component, present in the data, and facilitate its interpretation, the data was using a background removal filter, a band pass filter, and migration. Subsequently, the profile acquisition plan, based on a 0.25 m grid, made it possible to spatially correlate, in 3D mode, the anomalies present on each 2D section using the analysis of the amplitude reflections events within assigned time intervals (time slices). This type of analysis (Leucci, 2019) gave satisfactory results that facilitated the interpretation of the anomalies. Slices of amplitude were then constructed at time intervals of 5 ns for the 600MHz antenna, so that each slice corresponds to a ground thickness of about 0.25 m (with an average propagation velocity of the electromagnetic wave equal to about 0.1m/ns). The blue color indicates weak amplitude of the reflected signal (substantially homogeneous material); the colors from light blue to the most intense red indicate variations in the amplitude of the reflected signal and therefore the presence of significant electromagnetic discontinuities. The variations of amplitude (therefore of color) in the same slice indicate horizontal variations in the electromagnetic characteristics of the investigated medium. To better understand the 3D distribution of anomalies, referable to probable structures of archaeological interest, the electromagnetic wave amplitude iso-surfaces were created to assist in correlating anomalies of a given amplitude in 3D and isolating them by subsequently setting a threshold value. Finally, the drone photographic survey of the investigated areas and the measurement of their exact extension allowed the creation of a sort of virtual excavation carried out with the insertion of anomalies within the investigated areas, facilitating the interpretation of the geophysical anomalies in relationship to existing structures.

Figure 2 Areas investigated with GPR

This paper reports the results related to area 1. Area 1 has been divided into two areas called area 1A and area 1B respectively (Fig. 3).

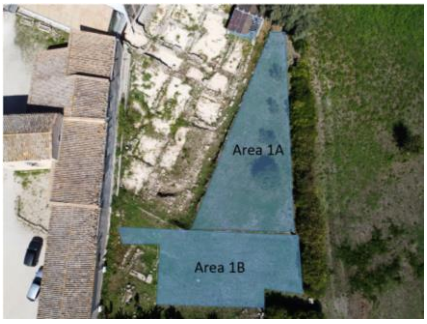

Figure 3. Area 1

The analysis of the data for area 1A highlighted a good penetration of the electromagnetic signal which allowed to investigate up to a depth in times equal to 70 ns (for the 600MHz antenna) which corresponds to a depth of about 3.5 m, considering an average speed of propagation of electromagnetic waves in the subsoil is equal to about 0.1 m / ns. Fig. 4 shows the amplitude slices relating to the 600MHz antenna. The amplitude slices identify the extent of probable structures of archaeological interest (walls), indicated with black dotted lines. The depths vary on average from 0.4 m to 1.1 m.

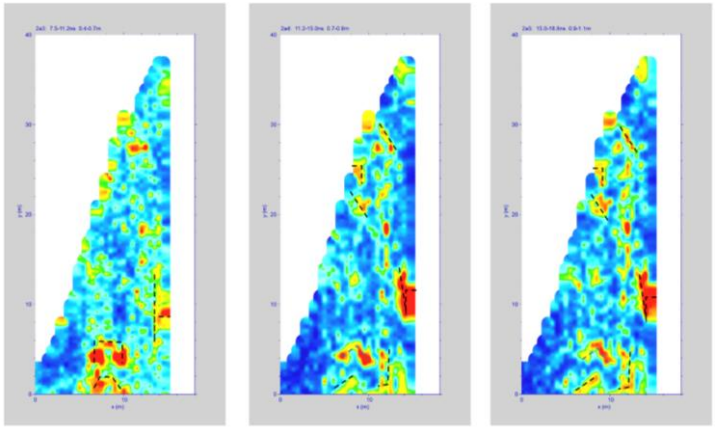

Figure 4. Area 1A: the time slice

Fig. 5 shows the iso surfaces of electromagnetic wave amplitude that better highlight the probable structures of interest.

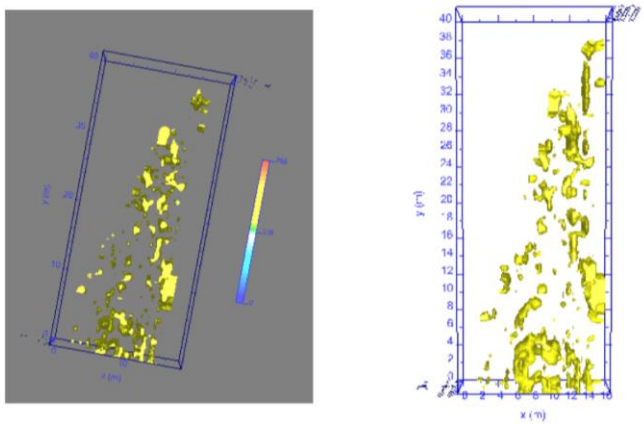

Figure 5. Area 1A: 3D visualization by iso-surface amplitude

The analysis of the data for area 1B showed good penetration of the electromagnetic signal, reaching a depth in time equal to 70 ns (for the 600MHz antenna) which corresponds to a depth of about 3.5 m, considering the average speed of propagation of electromagnetic waves in the subsoil equal to about 0.1 m / ns. Fig. 6 shows the amplitude slices relating to the 600MHz antenna. In them it is possible to identify the extent of the probable structures of archaeological interest (walls) indicated with black dotted lines. The depths vary on average from 0.4 m to 1.5 m.

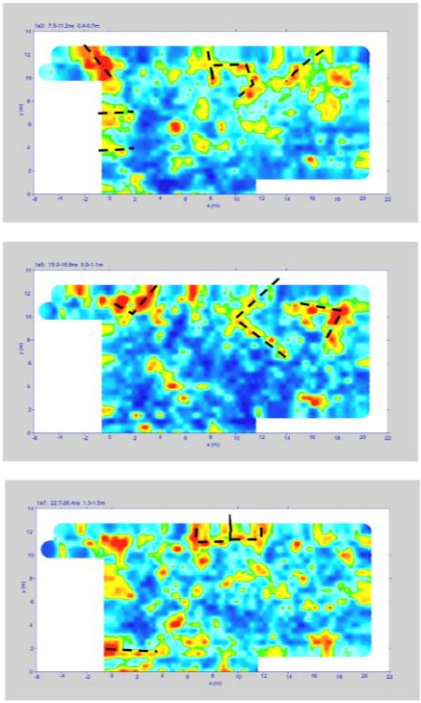

Figure 6. Area 1B: Time slices

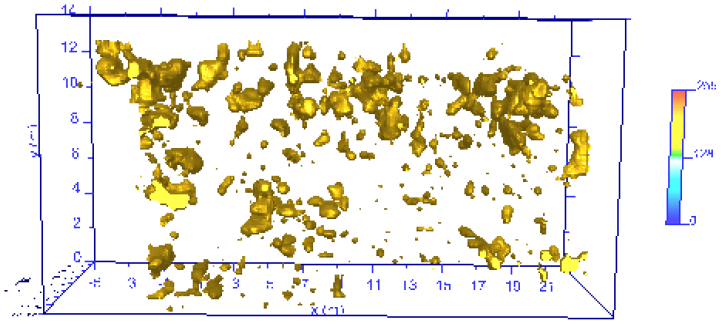

Figure 7. Area 1B: 3D visualization by iso-surface amplitude

Fig. 7 shows the iso surfaces of electromagnetic wave amplitude that best highlight the probable structures of interest.

3. Conclusions

Overall, the geophysical investigations carried out have provided good results in identifying structures present in the subsoil. Specifically, using GPR made it possible to investigate the subsoil up to a depth of approximately 4 m, highlighting anomalies in the first 2 m of depth. The identification of a number anomalies, including likely walls, is highlighted. Fig. 8 shows the superimposition of the anomalies identified on the drone photo in a sort of virtual excavation.

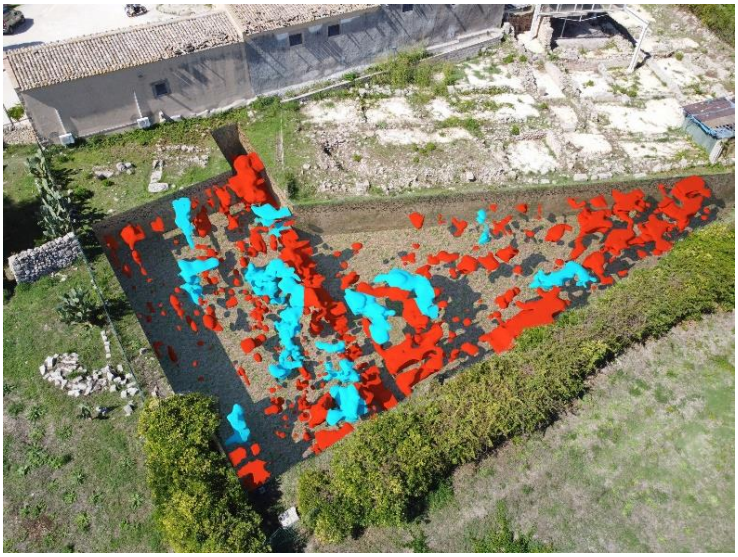

Figure 8. Superimposition of anomalies identified on the drone photo

The data obtained during the GPR survey conducted at the site of the Roman villa of Caddeddi shows significant anomalies in unexcavated areas of the site. The preliminary results relating to Area 1 are presented here, shedding light on the presence of important archaeological features yet to be uncovered and interpreted. Such findings will be essential in the development of a future road map for resuming the systematic archaeological investigation of the most relevant Late Roman rural residence of southeastern Sicily.

References

[1] Voza G. 1972-1973, Attivita' della Soprintendenza alle antichita' per la Sicilia Orientale, in Kokalos 18-19, 1972-1973, pp. 190-192.
[2] Guzzardi L. 2014, Nuove scoperte nel siracusano, in P. Pensabene, C. Sfameni (eds), La Villa restaurata e i nuovi studi sull'edilizia residenziale tardoantica. Atti del Centro Interuniversitario sull'Edilizia nel Mediterraneo (CISEM), Piazza Armerina 7-10 novembre 2012, Bari: Edipuglia, pp. 29-36.
[3] Accolla M. 2020, Nuove indagini nell'area a Sud-Est della villa romana del Tellaro (2010-2011), in R. Amato, G. Barbera, C. Ciurcina (eds), Siracusa, la Sicilia, l'Europa. Scritti in onore di Giuseppe Voza, Palermo: Torri del Vento, pp. 343-350.
[4] Garipoli S. 2018, Nuovi dati sui cimiteri di rito islamico in Sicilia. Il gruppo umano del cimitero di Contrada Caddeddi (Noto), Cronache di Archeologia 37, pp. 435-448.
[5] Wilson G. 2016, Caddeddi on the Tellaro. A Late Roman Villa in Sicily and its Mosaics, (BABesch Supplement 28), Leuven: Peeters.
[6] Conyers L.B. 2004. "Ground-penetrating Radar for Archaeology", Altamira Press: Walnut Creek, 2004 California.
[7] Leucci G. 2019. "Nondestructive Testing for Archaeology and Cultural Heritage: A practical guide and new perspective", Springer, Berlin, Germany, 2019.
[8] Leucci G. 2020. Advances in Geophysical Methods Applied to Forensic Investigations: New Developments in Acquisition and Data Analysis Methodologies. Springer editore, pp 200, ISBN 978-3-030-46241-3