

Ground remote sensing surveys to investigate mounds tombs from Etruscan period. The case of Monte Abatone necropolis (Cerveteri, Italy)

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Abstract – The Monte Abatone Project is based on the employment of different methodologies to reconstruct the limits of the necropolis and the location of all different tombs. In the period between 2018 - 2021, geophysical surveys have been carried out to investigate the unexplored portions of the ancient Necropolis. Ground Penetrating Radar and the Magnetometric methods have been systematically employed to investigate about twelve hectares of the necropolis. GPR systems equipped with a 400 MHz antenna, a dual frequency antenna with 300/800 MHz and the Kontur 3D-Radar Geoscope multichannel stepped frequency system were employed to survey the selected areas.

All the GPR profiles were processed with the aim to obtain a 2D visualization (time-slices) of all reflections in the ground.

The obtained results clearly show the presence of a network of strong circular or rectangular features, linked with the buried structural elements of the searched chamber or pit tombs.

I. INTRODUCTION

Geophysical methods are frequently used in archaeological prospection in order to provide detailed information about the presence of structures in the subsurface as well as their position and their geometrical reconstruction, by measuring variations of some physical properties [1]. Often, due to the limited size and depth of an archaeological structure, it may be rather difficult to single out its position and extent because of the generally low signal-to-noise ratio. This problem can be overcome by improving data acquisition, processing techniques and by integrating different geophysical methods [2].

In this work, which is part of a project jointly developed between the Campania University “Luigi Vanvitelli” (Caserta) Prof. F. Gilotta, the Tuscia University (Viterbo) Prof. M. Micozzi and A. Coen, the Bonn University, Prof. M. Bentz and ISPC (CNR), geophysical surveys employing Ground Penetrating Radar and Magnetometry methods to investigate areas of the Monte Abatone necropolis (Cerveteri, Italy) have been carried out.

The city of Cerveteri is located in the Latium Region, about 60 Km North of Rome, in Italy. The study area is situated about 1.5 Km south-east of the modern town of Cerveteri in the area of the Necropolis of Monte Abatone. This is one of the main necropolis of Cerveteri. In this area, several tombs have been discovered and excavated from the 1800, though still many remain buried underneath the subsurface.

The necropolis of Monte Abatone is part of a settlement dating from the 7th to the 3rd century B.C. part of it was brought to light during the first excavations of the second half of the 1800s and, subsequently expanded with the recovery interventions of 1944. The most important and predominant features in the area are the tombs dating back to the 7th century, which show a very particular and original plan. Most of them are mounds tombs, predominantly with chamber rectangular rooms, which are dug into tuff formations. The most significant examples are represented by the Campana mound and the Torlonia tomb. The sepulchral structures are bounded by circular trenches, interrupted only by the entrance corridors (dromos). The circular complexes have diameters ranging from 10 to 30 meters, and the distance between the tombs of the necropolis is of a few meters.

The area of the necropolis is characterized by a tuffaceous covering of piroclastic origin; the tuffaceous layer, ten meters thick, is the site of the necropolis.

II. METHODS

In the period between 2018 and 2021, geophysical surveys have been carried out to investigate the unexplored portions of the ancient necropolis, to provide a complete mapping of the position of the searched tombs. Ground Penetrating Radar and the Magnetometric methods have been systematically employed to investigate about twelve hectares of the necropolis. GPR system SIR3000 (GSSI), equipped with a 400 MHz antenna with constant offset, SIR4000 (GSSI) equipped with a dual frequency antenna with 300/800 MHz and the Kontur 3D-Radar Geoscope multichannel stepped frequency system were employed to survey the selected areas where the presence of tombs was

hypothesized from previous archaeological studies. The data positioning has been done with RTK GNSS antenna. Furthermore, differential magnetic surveys were carried out using the Geoscan FM256 in the areas, overlapping the GPR acquisition.

Magnetometry: the selected areas were investigated employing the differential magnetic method. Area A which covered a surface of 360 x 152 m, was divided in 30 x 30 m grids; area B (60 x 40 m) was divided in six 20 x 20 squares. The vertical gradient of the total magnetic field was measured using a Fluxgate gradiometer FM256 (Geoscan Research, UK) along parallel profiles with a horizontal spacing of 1 m and with a sampling interval of 0.5 m.

GPR: for the GPR measurements, data were collected, along parallel profiles, employing the SIR3000 and SIR4000 (GSSI) systems, equipped with a 400 MHz (GSSI) bistatic antenna and a dual frequency antenna with 300/800 MHz with constant offset. The horizontal spacing between parallel profiles used was 0.5 m for all areas. The spacing was chosen based on the indications of archaeologists regarding the size and dimension of the hypothesized structures in the different areas. After the usual preliminary tests, the acquisition parameters have been set to a time window of 90 ns (tw), according to the environmental conditions of the ground and on the depth at which the structures rest below the subsurface. Data was acquired as 16 bit (for SIR3000) and 32 bit (for SIR4000) and 512 samples per radar scan.

The Kontur GPR array uses all frequencies between 200-3000 MHz. The surveys have been collected with DXG1212 array (12 channels, 7.5 cm spacing) in 2019 and

DXG1820 array (20 channels, 7.5 cm spacing) in 2021.

III. PROCESSING AND RESULTS

The magnetic data was processed with Geoplot 3.0 software (Geoscan Research). After de-spiking, filtering and rearranging processes, the data were assembled in a contour map of the vertical gradient of the total magnetic field (fig. 1). The contour map (fig.1) shows the obtained results; this map is characterized by many magnetic anomalies with linear and circular shapes. These last character is related to the presence of the searched tombs.

All the GPR profiles collected with standard equipments (SIR3000 and SIR4000) were processed with GPR-Slice v7.0 Ground Penetrating Radar imaging software (Goodman 2021). The basic radargram signal processing steps included: post processing pulse regaining; DC drift removal; data resampling; band pass filtering; background filter and migration. With the aim of obtaining a planimetric vision of all possible anomalous bodies, the time-slice representation was calculated using all processed profiles showing anomalous sources up to a depth of about 2.5 m (fig.2) [3]. Fig.2 shows a portion of the area investigated employing the GPR SIR3000 with 400 MHz antenna. Also in the case of GPR results it is possible to observe that few anomalies, close to the surface, are characterized by a circular shape in correspondence of the tombs. The time-slices related to the deeper depths show anomalies with rectangular shape, due to the presence of a rooms inside the tombs.



Fig.1 – Monte Abatone Necropolis. Gradiometric map of the investigated area. Range -15, +15 nT/m.



Fig.2 – Monte Abatone Necropolis. GPR SIR3000 with 400 MHz. Time slices at the estimated depth of 0.40 m

The GPR profiles collected with Kontur GPR equipments 3D-Radar were processed with Examiner v 3.5 software (Kontur). The basic radargram signal processing steps included: time zero calibration, IFFT; low pass filtering; background removal filtering; range gain. The profiles on time-slice view show the anomalous sources up to 2.5 m depth, (fig.3a). Also in this case, the time-slice related to the depth of 0.30 m from the surface, is characterized by the presence of many circular anomalies due to the external structure of the tombs. Fig. 3a represents a general overview of the area investigated with the 3D Radar. Fig. 3b represents the detail of the southern portion of the area, where the circular anomalies due to the tombs sought are visible. This figure represents the enlargement of the red box of fig. 3a, where it is possible to see the time slices corresponding to the antenna width and the paths taken.

IV. CONCLUSIONS

Employing geophysical methods to investigate unexcavated areas of Monte Abatone necropolis site allowed us to recognize features which are compatible with the information given by the archeologists in terms of architecture and structure type. Together with archaeologists, the obtained anomalies have been interpreted to have a good matching with the

expected searched tombs. These results have enhanced the knowledge of the necropolis layout and mapping. After the geophysical surveys, direct excavations have been conducted during 2018-2021, which brought to light few of the investigated structures, (fig.4). The obtained results, after the excavation, have been compared and integrated with the geophysical maps to define the keys for the interpretation.

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Fig.3a – Monte Abatone Necropolis. GPR Kontur 3D-Radar Geoscope. Time slices at the estimated depth of 0.30 m

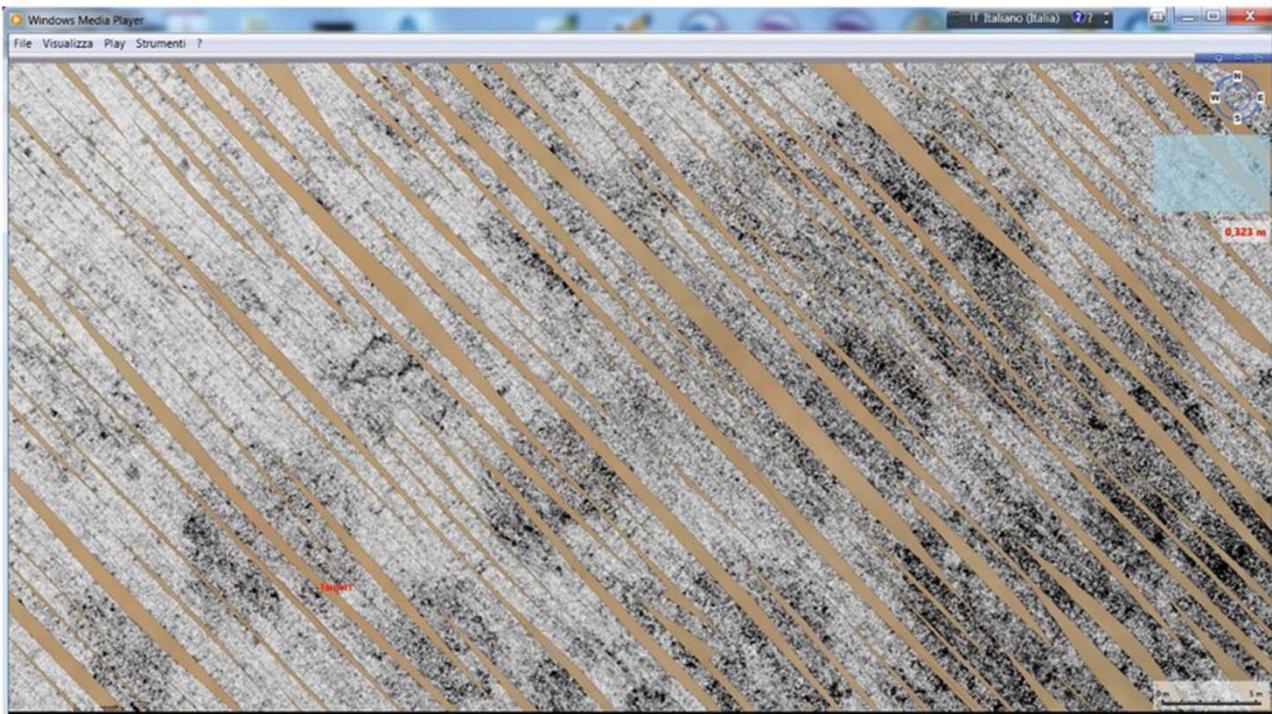


Fig.3b – Monte Abatone Necropolis. GPR Kontur 3D-Radar Geoscope. Time slices at the estimated depth of 0.30 m. Enlargement of the red box of the fig. 3a.



Fig.4 – Monte Abatone Necropolis. Archaeological excavation September 2018.