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Geophysical Survey and Archaeological Data at Masseria Grasso (Benevento, Italy)

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Abstract

The use of geophysical methods in metrology is a significant tool within the wide research topic of landscape archaeology context. Since 2011, the Ancient Appia Landscapes Project aims to recognize dynamics, shapes and layout of the ancient settlement located along the Appia road east of Benevento, and cyclical elements and human activities that influenced the choice of landscapes. The integration of geophysical data with an archaeological infra-site analysis allowed us to investigate the area of Masseria Grasso, about 6 km from Benevento (Campania region, Italy). In this framework, an archaeogeophysical approach (Geomagnetic and Ground Penetrating Radar) was adopted for detecting anomalies potentially correlated with buried archaeological evidences. The geomagnetic results have given a wide knowledge of buried features in a large survey highlighting significant anomalies associated with the presence of buildings, roads and open spaces. These geophysical results permitted us to define the first archaeological excavations and, successively, a detailed Ground Penetrating Radar approach has been provided highlighting the rooms and paved spaces. The overlap between archaeological dataset and geophysical surveys has also allowed recognizing the path of the ancient Appia road near the city of Benevento and hypothesize the settlement organization of the investigated area, which has been identified with the ancient *Nuceriola*.

Keywords Archaeogeophysics · Geomagnetic · GPR · Ancient Appia road

1 Introduction

This paper deals with the results of an archaeogeophysical approach based on the comparative use of Geomagnetometric (GM) and Ground Penetrating Radar (GPR) measurements with an archaeological study. Among the various geophysical techniques, the most interesting and effective are the geomagnetic and electromagnetic techniques that are able to locate and identify archaeological structures at different scale and depth with good resolution in

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different scenarios. The growing interest in non-invasive and fast techniques able to localize and identify the presence and geometry of archaeological unearthed structures has led to the creation of an important discipline based on combined use of archaeological and geophysical knowledge, which is called *Archaeogeophysics*. This specific topic is part of the more general geoarchaeology, and it is based on the use of different geophysical techniques able to detect contrasts of physical properties of the subsoil associated to archaeological buried structures. The integration of different techniques reduces the uncertainties of the interpretation and permits is to investigate archaeological structures placed in different contexts without interfering with economic and social activities. Moreover, the archaeogeophysics improves the integration between the classical archaeological observations and the geophysical results in order to identify the best image of buried structures (Rizzo et al. 2005, 2010; Piro 2009; Peregrine et al. 2012; Leucci et al. 2015).

During the last three decades, GM surveys have been often used to identify buried remains and structures providing excellent results. Among the geophysical techniques which can be employed for the archaeological research, the geomagnetic method seems to be the most suitable and the most largely exploited because of its reliability and for the aptitude to provide quick data acquisition, non-invasive investigation and high-resolution experimental data. However, its usefulness is drastically reduced in urban areas because the electromagnetic noise due mainly to the presence of objects. Generally in the preliminary phase of archaeological investigation, GM surveys are very able to delimitate archaeological areas of interest with an acceptable resolution reducing time of acquisitions without, nevertheless, giving information on the depth of the anomalies. Then, in a secondary phase, GPR measurements should be adopted to enhance the quality of the acquired data and focus on the anomalies. For this reason, the two techniques are often used in tandem (Chianese et al. 2004, 2010; Rizzo et al. 2005, 2010; Piro 2009; Capozzoli et al. 2017).

Although governed by the same fundamental equations, magnetic and electromagnetic surveys are very different. GM survey measures the variation of the magnetic field of the Earth and the effects caused by anthropogenic artifacts located in it. The physical property investigated is called magnetic susceptibility that is characteristic for each magnetizable material and depends mainly on the volume per cent content of magnetite. The induced magnetization in a rock due to the Earth's field, F is directly proportional to magnetic susceptibility. Further, a remanent magnetization phenomenon should be considered added to the one caused by Earth's field due to the thermoremanent magnetization acquired by magnetic grains during cooling from the Curie temperature to normal atmospheric temperature in the presence of an external field.

Actually, there are three types of magnetometer-fluxgate, proton precession and alkali vapour that can be used singly or in tandem in gradiometer array. Gradient measurements emphasize archaeological contrasts allowing the differentiation between deeply buried objects versus those that are shallower. Usually, parallel lines spaced 1 m apart for square area define a geomagnetic survey. Data are generally acquired in continuous mode and processed with the use of bandpass filters to enhance archaeological features and eliminate events, referred to as spikes, that are attributable to the presence of alignments due to recent anthropogenic activities (Piro 2009). In particular, the successful application of geomagnetic measurements to identify archaeological features is shown in particular to identify the presence and distribution of archaeological remains (Rizzo et al. 2005, 2010; Milsom and Eriksed 2011), map subsurface anthropogenic features and find buried tombs (Caggiani et al. 2012; Keay et al. 2014), detect walls and ceremonial areas also reconstructing the architectural plan of lost settlements (Cardarelli et al. 2008; Viberg et al. 2013; Masini et al. 2017).

The application of GPR for archaeological research is common, and several research papers have been published. There are many reasons for this success that made the GPR the most widely used geophysical techniques in the archaeological field. One of the most important is the high resolution of the method related to the operating frequency of the antenna. Moreover, the GPR has an acceptable depth of investigation for archaeological targets, generally ranging between 0.50 and 3.00 m depending on the conditions of the subsoil. Other GPR advantages are: the substantial indifference of the method with respect to the electromagnetic radiations that allows a wide application in urban archaeological areas where the magnetic method struggles; the high capacity of integration with other geophysical data (Goodman and Piro 2013). GPR is based on the study of the scattering phenomenon encountered by a high frequency electromagnetic signal introduced into the ground via antenna. The typical antennas for archaeogeophysical target have a range between 200 and 900 MHz, simultaneously generate and receive the EM signal while they are moved along profiles. The higher the operating frequency, the smaller is the investigated depth but the better is the obtained resolution. The dielectric permittivity influences strongly the EM velocity of propagation and the correct evaluation of these parameters is fundamental to identify the depth of the buried remains. While generally magnetic permittivity is neglected (but it must be carefully evaluated in presence of ferromagnetic minerals that can have a considerable effect on GPR wave velocity and signal attenuation), the static conductivity value assumes great importance because variations of this property generate a severe attenuation of the signal that in several cases can reduce heavily the investigation depth. This is the case of water-saturated soils (in particular with marine scenarios with salt water) or clay soils where the method is less effective (Daniels 2004; Annan 2009).

To effectively manage a GPR campaign, rectangular grids are established and profiles every half meter in at least two directions mutually perpendicular should be acquired to have a good reconstruction of remains into the soils. The acquired data, then, are processed via PC adopting filter that removes ringing noise or other disturbance sources and results often are showed using horizontal slices where the higher reflective areas are related to archaeological remains. The horizontal slices acquired in time domain are inverted in the space domain generating depth slices that are able to support archaeologists in managing the subsequent invasive excavations (Conyers 2006). Moreover, its success for archaeological prospections is shown by the increasing number of papers where the method is successfully used to detect buried structures in urban and rural areas and discover archaeological features in a great number of scenarios, such as to identify ancient settlements (Novo et al. 2008; Piro et al. 2011; Trinks et al. 2014), locate unearthed burials and ceremonial offering (Pipan et al. 2001; Rizzo et al. 2010), reconstruct the history of ancient buildings (Piro et al. 2003; Goodman and Piro 2009; Masini et al. 2017), image structures and infrastructure (Leucci et al. 2002; Ranieri et al. 2016), identify subwater structures (Capizzi et al. 2007; Simyrdanis et al. 2015; Capozzoli et al. 2017).

The outline of this paper is the following: in the second section the archaeological context will be described with a short summary of the adopted archaeological methodology. In the third section, the archaeogeophysical approach used in order to identify archaeological features will be discussed analysing and the results will be shown considering also the validation of geophysical data with the direct data obtained after the excavation activities.

2 The Archaeological Context

The Ancient Appia Landscapes Project (AAL), carried out by Dipartimento di Scienze del Patrimonio Culturale of University of Salerno, is developed in partnership with the Soprintendenza Archeologia, Belle Arti e Paesaggio delle province di Caserta e Benevento, the National Research Council (CNR-IMAA) of Tito Scalo (Italy, PZ), the University of Molise (GeoGisLab, Dipartimento Bioscienze e Territorio), the University of Sannio (Dipartimento di Scienze e Tecnologie). The research aims to study the path of Via Appia, the ancient road crossing the city of Beneventum, and to identify environmental phenomena, socioeconomic and productive activities that influenced settlement dynamics before, during and after the construction of the consular road (Fig. 1). The project is based on a multidisciplinary approach and a profitable exchange of knowledge between different topics, involving various methods and tools of investigation (study of archives, historical maps, paleobotanical analysis, surface surveys, remote sensing interpretation, geomorphological analysis) to perform knowledge of archaeological remains from a territorial dimension to an infra-site analysis (De Vita and Terribile 2014; Rossi and Santoriello 2014; Santoriello et al. 2015). This approach is based on some fundamental steps, which constitute the foundations of the modern discipline called landscape archaeology (Birks et al. 1988; Cambi 2011).

The first step was addressed to collect archaeological data previously published or stored in public archives. Then, an intensive survey allowed us to increase the archaeological record and to specify territorial patterns and settlement dynamics. The obtained information defined a first GIS-based archaeological map, which was combined with a geomorphological analysis in order to understand both the morphogenetic processes and the landscape geomorphologic stratification (De Vita and Terribile 2014). The final work was to reconstruct the ancient landscape through the identification of residual shapes in the

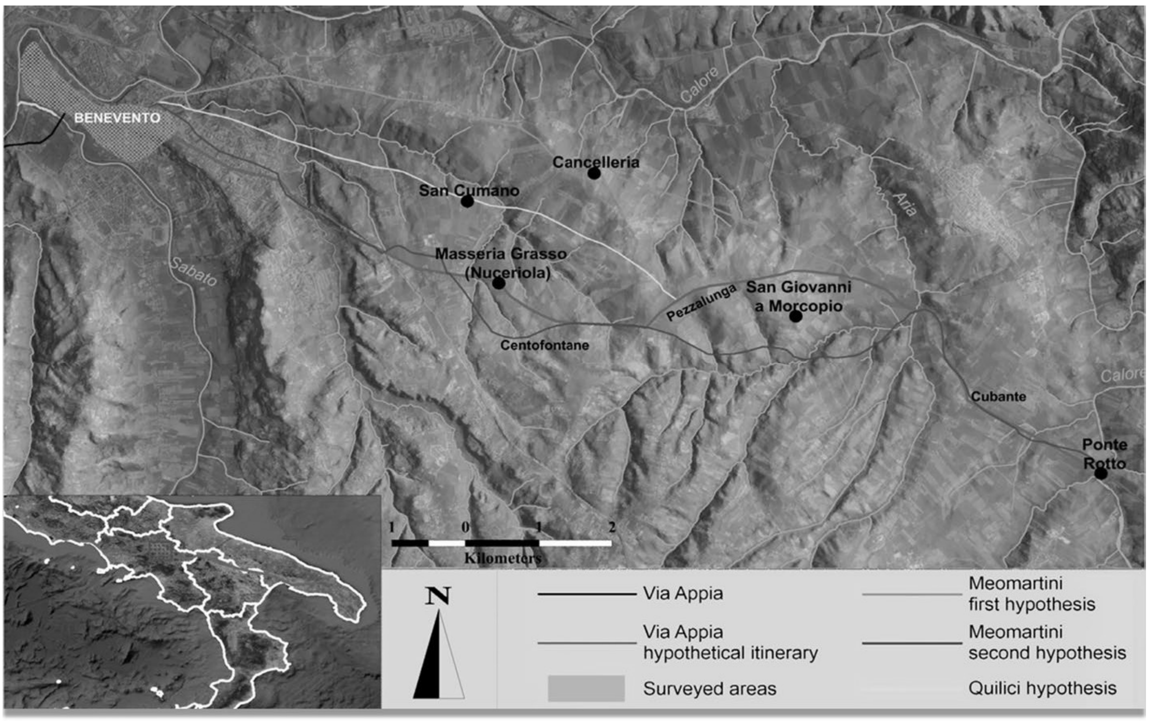

Fig. 1 Location of the archaeological site of Nuceriola (Masseria Grasso) supposedly placed along the Via Appia roadway

actual asset (Santoriello et al. 2015). As discussed by Chouquer et al. (1987) in the area east of the city of Benevento, two hypothetical cadastres were identified by the team of Besançon, dating back to the Triumviral period (Beneventum I, 20×20 actus, N 42°E) and to the Augustan era (Beneventum II, 16×25 actus, N 2°W). Recent considerations about Beneventan cadastres did lean towards a new dating: the years of the colonial foundation (after 268 BC) for the Beneventum II, the Triumviral–Augustan age for the Beneventum I. It has been suggested that a change of orientation occurs in the cadastre Beneventum II (16×25 actus), between Sabato river to the west and Calore river to the north-east: this layout is conditioned by the morphology and hydrographic system and has an orientation of N 42°E (Santoriello et al. 2015; Santoriello 2014). Furthermore, some orientations identified in the Cubante plain, near Ponte Rotto, have been considered as possible traces of a third centuriation of middle imperial age (20×20 actus, N 29°E). It seems to originate from the orientation of Ponte Rotto and to exploit the natural conformation of alluvial terraces.

According to the achieved results, it was decided, within the project, to start an investigation on a minor territorial scale, setting up infra-site activities in some of the most significant sites. In detail, archaeological surveys in the area of Masseria Grasso, at 6 km from Benevento, has recorded an important settlement of about 7 hectares, dated, with some temporal gaps, from the middle of fourth century BC to the sixth–seventh century AD. After all, the area was already known by a significant discovery at the beginning of the twentieth century: here, A. Meomartini found remains of a paved road interpreted as a section of the ancient via Appia (Meomartini 1907), iso-oriented to the hypothetical centurial system (N 42°E) later recognized by French scholars.

From a geomorphological point of view, the Masseria Grasso site is located on a large plateau disposed between watercourses characterized by steep slopes in constant erosion. However, the archaeological deposit placed on the terraced areas suffered minor dislocations, almost exclusively due to agricultural activities. Moreover, cartographic and photointerpretation analyses have returned some iso-oriented traces pertaining to Beneventum I centuriation, suggesting a strong preservation of the Roman landscape in the actual rural fabric. Over the period 2014–2017, areas with significant anomalies in terms of archaeological evidences have been investigated by geophysical surveys in order to confirm the presence of structures.

3 Geophysical Acquisition and Data Processing

An integrated approach was proposed during the investigation performed near the old Roman road “Via Appia” located near the modern town of Benevento where GM surveys and GPR acquisitions were adopted. Since 2014 geophysical activities were performed in this area in order to give a contribution to landscape work on the ancient settlement close Benevento archaeological area by the use of an extensive geophysical field trip. The GM measurements were taken using an optical pumping magnetometer G-858 (by Geometrics) in gradiometric configuration, with two magnetic probes set in a vertical direction at a mutual distance of about 1 m. Such a configuration allowed the automatic removal of the diurnal variations of the natural magnetic field. Before defining the acquisition modalities, it was necessary to set up the proper orientation of the two magnetic sensors of the Caesium Magnetometer. Such an orientation depends on the survey direction and site location in the world. To do this CSAZ software (by Geometrics) has been used. It provides information about the Earth’s magnetic field parameters including total field, inclination and declination anywhere in the world, using the IGRF (International GeoMagnetic Reference Field). After entering latitude and longitude of the archaeological site and indicating the survey direction, the software provides the orientated caesium sensor to have the maximum signal and best performance. Therefore, the instrument was set with a tilt angle of 90° and the survey was defined along parallel profile in N-S direction. Data were acquired along parallel profiles 1 m apart with a sampling rate of 10 Hz, obtaining a mean spatial resolution of 1.0 m × 0.125 m, and 17 Maps were acquired with the gradiometric system for a total investigation surface of about 30.875 mq (Fig. 2a).

All the geomagnetic acquired data were processed in a first phase with MagMap software (Geometrics) in order to improve the acquired geomagnetic image from the zig-zag errors, due to operator walking. This process permits us to obtain a first level of raw GM data where the anomalies due to linear buried structures are arranged for true distribution. The second step the raw data was elaborated by TerraSurveyor software (DW Consulting) that provides a wide range of processes, allowing the data to be manipulated to produce the best geomagnetic anomalies distribution. In detail, the geomagnetic raw data have been filtered to increase the signal/noise ratio providing: a clip process, to remove

Fig. 2 **a** Investigated area where the GM (blue area) and GPR (yellow area) surveys were carried out. The pink surface is the excavated archaeological area of Masseria Grasso (Saggio 3). **b** Saggio 3 with the surrounding GPR survey area (black areas). All the numbers define the distance in meters

extreme datapoint value; a de-spike filter, to remove spikes caused by small surface iron anomalies; de-stagger filter, to compensate for data collection errors caused by the operator starting recording each traverse too soon or too late; destripe process, to equalize underlying differences between grids and to reduce the linear features. Finally, the processed data are visualized in a regular grid using a Kriging interpolator with a linear variogram (Surfer software), in order to highlight the main magnetic anomalies (Fig. 3).

The GPR surveys were performed with a RIS MF Hi-Mod GPR System of IDS equipped with an array of two multi-frequency antennas using simultaneously 200 and 600 MHz antennas mounted on a survey cart equipped with an incremental encoder. The 200 MHz and 600 MHz data were acquired in continuous and reflection mode with a time window of 120 ns and 90 ns, respectively, samples per scan set at 512 with a resolution of 16 bits and a transmit rate of 100 kHz. With this set-up, the data were acquired on an area of about 150 m^2 characterized by the presence of some obstacles such as the excavated area and some mounds of earth related to the excavations activities. For this reason, the whole area was subdivided into four areas with limited size (Fig. 2b). For investigating each area, a regular grid was adopted. In detail, the grid was based on measurements every 1 m according to two main directions mutually perpendicular. The surface of the investigated site was rough, and the presence of vegetation did not provide optimal conditions of acquisition and for this reason is impossible to use a more accurate step of acquisition with closer profiles. The GPR acquisition was supported by a topographic survey that gave the possibility to georeference the obtained data that were managed with a CAD software. The

Fig. 3 Geomagnetic results of the Masseria Grasso archaeological site

raw data have required some processing operations addressed to reduce the noise of the measurements and attenuation phenomena. In order to process the 2D-data, some classical operations were chosen according to a simple scheme with the support of the software Reflex-W based on the following steps: Editing of the data to assign the right coordinate according the defined grid of acquisition; amplitude normalization of the traces normalizing their amplitudes with the mean amplitude value measured along the complete radargram; application of the background removal filter that provide to remove the average of all background noise that influence the data; use of a gain function to amplify the measured signal based on a mean amplitude decay curve determined from all existing traces; use of bandpass frequency filter to reduce the increase in noise affecting the radargram caused by the gain function previously adopted and other source of noise; time cut to properly reduce the adopted time window until the signal was "clean" and appropriate on the basis of archaeological data; migration of the data based on the Kirchhoff algorithm with a velocity estimated quantitatively using the diffraction hyperbolas generated by potential archaeological features. Then, the processed data were interpolated to realize the 3D reconstruction of the investigated subsoil considering an interpolation distance equal to twice the used step of acquisition (i.e. 2 m). The volume was discretized according to a 3D fine grid defined by the envelope of the amplitude values calculated each 0.15 m in the two main directions. From the 3D data volume, every 0.20 m the depth slice was extracted and georeferenced in CAD to manage and facilitate the interpretation of the data.

4 Interpretation of Data and Discussion

The geomagnetic results were combined with the archaeological surveys, in order to provide useful information on the first excavation zone. The results provided an identification of several magnetic anomalies related to the presence of a significant buried archaeological record (Fig. 4). In detail, the geomagnetic map shows several iso-oriented anomalies potentially related to the presence of buried structures, which should occupy the entire northern portion of the investigated area: they probably prove the presence of relevant buildings, roads and open spaces belonging to a multi-stratified site. In the central portion of the geomagnetic map, significant geomagnetic anomalies are well depicted: they are 7 m wide and visible for about 100 m along a straight line with orientation N23°W. A similar anomaly is highlighted through the analysis of aerial photographs of 2006 shown in Fig. 5. Along this important axis, at least three orthogonal traces of smaller size (about 4 m wide) seem to define regular spaces, marked by another N23°W trace on the east side. These rectangular shaped areas show a considerable complexity probably resulting from the division of the interior spaces of some buildings. Their size (about 35×53 m) may correspond with a block measuring 1×1.5 actus (1 actus, a Roman unit of length, is about 35 m).

At last, in the southern portion of the map a large number of dipolar anomalies are well depicted and they should be related to the presence of significant traces of fire. Following the interpretation of the geomagnetic results, an archaeological excavation was set up in 2015–2017 in the southern portion of Masseria Grasso (Fig. 6). Therefore, two archaeological excavations (namely Saggio 1 and Saggio 2) have confirmed the presence of an ancient road at about 80 cm beneath the soil, consisting in the overlap of several levels of use (Fig. 7). It was possible to identify the oldest level of frequentation, which returned some fragments of ceramics (mainly a black-glazed cup Morel 1552) dating between the end of the IV and the first half of the third century BC. The most recent stratigraphy is strongly

Fig. 4 Geomagnetic results of Masseria Grasso area with interpretation of the main anomalies (red continuous lines)

disarranged by ploughing, but shows several maintenance interventions and raising of the road level through further cobbles arrangements that can be dated at least until the fifth–sixth century AD. On the geomagnetic map, the track of the road appears extremely weak, perhaps because of the bad conservation of the structure. However, some anomalies parallel to it show how the path may have influenced the shape of further buried evidences. The discovered road is about 5.6 m wide (19 pedes), compatible with the width of some ancient roads.

In Fig. 8, the representation concerns the projection of the excavated road related to the 20×20 actus centuriation, hypothesized by the équipe of Besançon in the eighties. We support this system (Chouquer et al. 1987, p. 159–164) reconstructed through a methodology approved by many researchers. Iso-oriented traces recognized on actual landscapes—according to the archaeomorphologic approach—are not necessarily archaeological objects, but rather relics or a propagation of an ancient pattern that still remains in the actual rural fabric. The track seems to change its orientation to the North, at the entrance of the ancient settlement, where the trace seen in geomagnetic map (with the orientation N 23°W) seems to be its natural continuation. Moreover, a third archaeological excavation (Saggio 3, in Fig. 7) located further north has confirmed this hypothesis. In this area, a building of at least 300 sqm is arranged along the hypothetical projection of the road. Because of agricultural activities, the structures appear

Fig. 5 Orthophotograph 2006 in false colours with identification of the most interesting crop marks (red arrows)

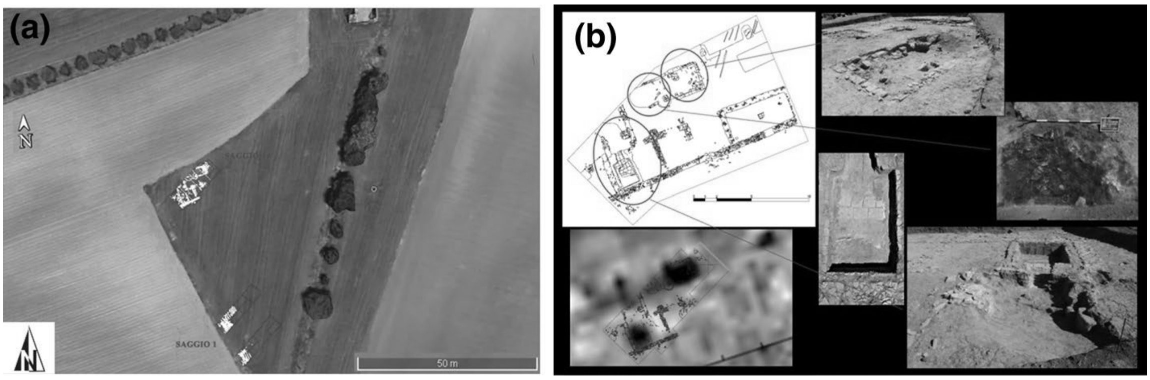

Fig. 6 Topographic map of archaeological excavations (**a**); the kilns in Saggio 3 area (**b**): the significant traces of fire in the geomagnetic map and the excavated structures

to be levelled almost entirely at a depth of 30–40 cm; at the moment, there are no traces of any foundation. The building is composed by a long perimeter wall brought to light for about 25 m, on which several spaces of regular shape are distributed. The construction technique is poor and of low quality—mainly, roof tiles sherds, limestone cobbles and mortar are used. It suggests, together with the reduced thickness of walls, mostly a separation function of workshop spaces. In the northeast sector, at least one open area is recognizable. Two small kilns were excavated inside the building: they are rectangular and show an access slide dug into the soil, with a praefurnium and a combustion chamber. The walls are made mostly of refractory bricks, with signs of firing. The presence

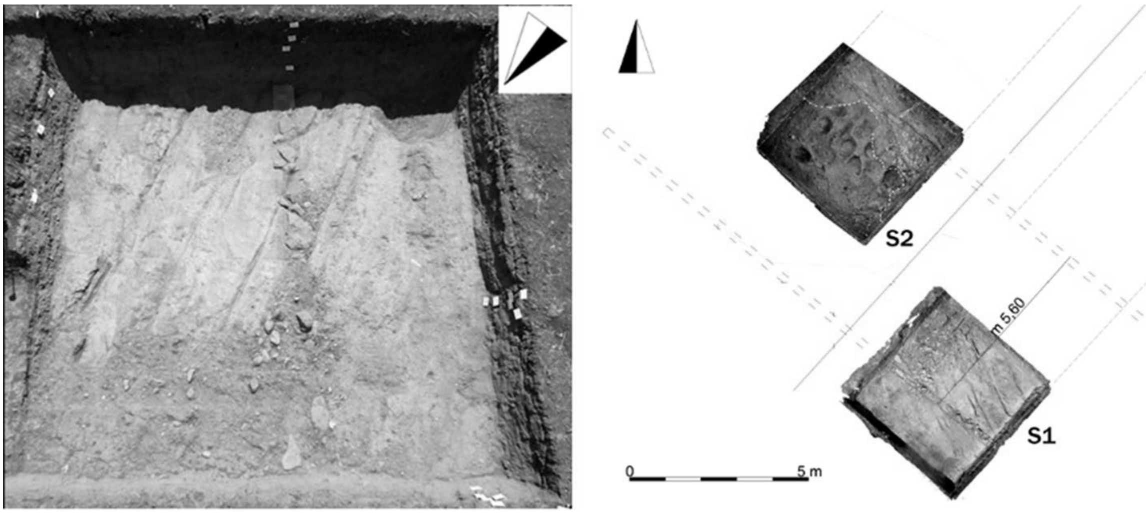

Fig. 7 Photograph of the Saggio 1 and Saggio 2 archaeological excavation with the remains of an ancient road

Fig. 8 The area of Masseria Grasso and the Triumviral–Augustan cadastre: the projection of the ancient road in red, the centuriation grid (20×20 actus) in orange (from Chouquer et al. 1987), the iso-oriented and degradated shapes in blue. The red circle is the excavation zone

of many sherds, including thin-walled pottery with a great number of kiln wastes suggests a production complex dating between the Augustan–Tiberian era and the half of first century AD (Santoriello 2017). The kilns are both related to the dipolar anomalies highlighted on the geomagnetic survey: similar anomalies are found in the southern sector of Masseria Grasso, and could suggest further production areas. Among the surface materials, there are fragments of metallic slags and other kiln wastes. After the excavation made by archaeologists that have confirmed the validity of the geomagnetometric results, some limited areas around Saggio 3 were investigated by Ground Penetrating Radar (GPR) acquisitions in order to enlarge the information related to the excavated area. The data acquired identified very interesting reflections within the depth ranging between 0.20 and 0.80 m as the radargram of Fig. 9 shows. Since the buried archaeological structures appeared so shallow, in accordance with the information of archaeologists, only the data obtained at the greater frequency characterized by a better resolution are considered. As plotted the time slices GPR images in Fig. 10, despite a inhomogeneous distribution of reflections, it was possible to define some area more reflective associable to the presence of walls and structures with orientation in good agreement with the already excavated materials. The anomalies found in the GPR survey can support the reconstruction of the entire complex, currently only partially excavated.

In Fig. 11, a detailed representation of the reflections measured at the theoretical depth of about 0.40 m are shown. The time slicer GPR image highlights several reflections aligned to some walls yet excavated at the east of the investigated area and the results suggest a prosecution of the main structure characterized by quadrangular rooms of limited size as highlighted (black dashed lines in Fig. 11). Another trace of considerable intensity is intercepted from north to south with a thickness ranging from 3 to 4 m. The response of the GPR shows a substantial difference both in relation to anomalies certainly referable to walls, and to those corresponding to paved spaces where a minor road could be connected with that observed in the geomagnetic map on the northeast part. This observation supports the hypothesis of a regular pattern of the settlement starting at least from the second half of the first century BC. At the same time, the reflections on the east corner of the time slicer image highlight the presence of a second structure not yet discovered. Further, some anomalies are placed to the south of the excavation; however, in this case the alignments of the reflective bodies are less in agreement with the existing structures, and it is not clear yet if there were further buildings beyond the unearthed complex.

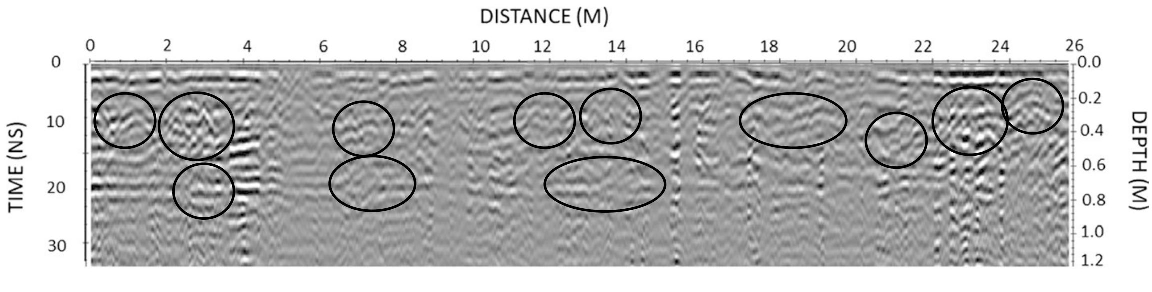

Fig. 9 One of the acquired radargrams highlighting different reflectors due to buried archaeological structure of the building. Circle black lines indicate reflections due to some buried structures (walls, roof, small channel, etc.)

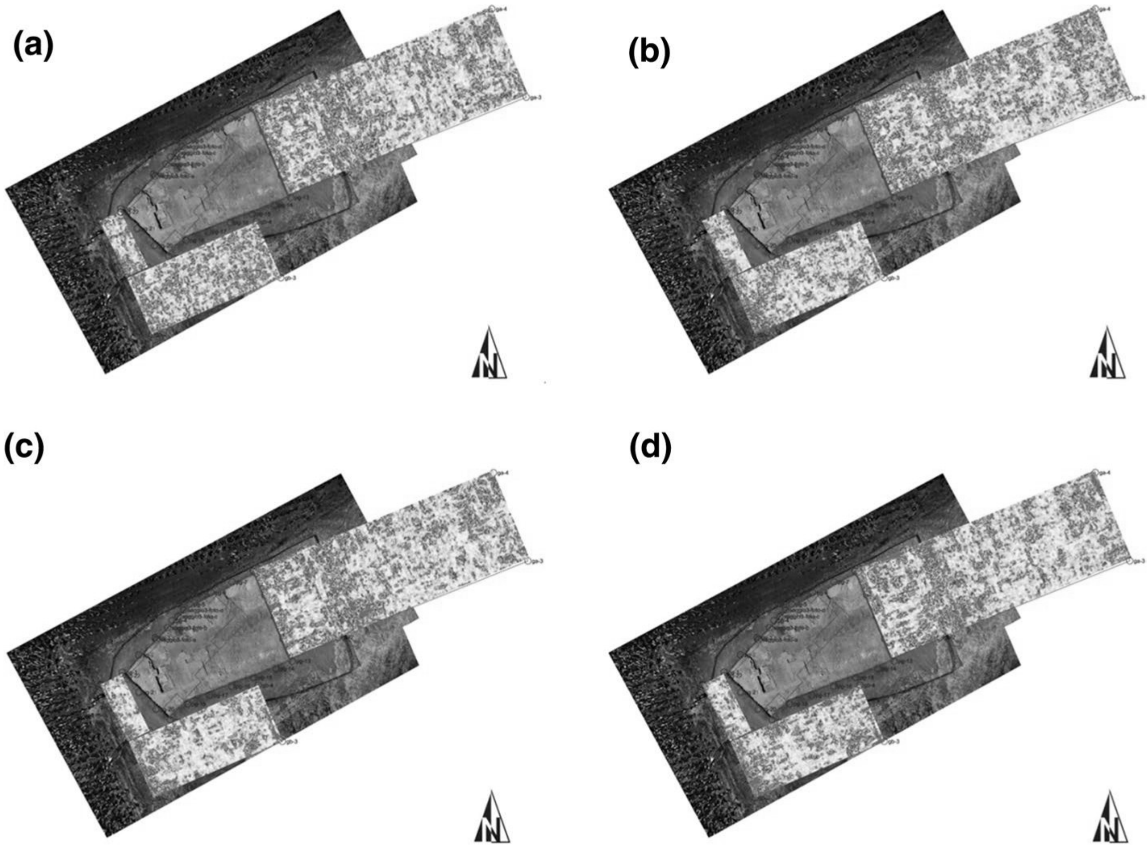

Fig. 10 Depth slices extracted at different depths, respectively, equal to 0.20 m (**a**), 0.40 m (**b**), 0.60 m (**c**) and 0.80 m (**d**). The strong reflections (red colours) individuate the presence of well-defined structures with alignments consistent with the existing ones

5 Conclusions and Future Perspectives

The described work has shown an important integration of different approaches from the landscape analysis to a geophysical survey and classical excavations. The multiscale information has been obtained by advanced research technologies and classical approach as the key to contribute to the interpretation of the complexity of the archaeological problems. The presented approach, based on the use of different tools of investigation, highlights how a close and synergistic collaboration between disciplines is a good starting point for planning excavation activities saving time and money. Moreover, the integration of different techniques can effectively support the detection of a potential archaeological site from one side, while from the other one can give the possibility to reconstruct the ancient urban and rural planning without expensive excavations or strongly reducing them. In detail, the site of Masseria Grasso occupies the whole plateau, as shown by the extended area of ancient fictile fragments found on the surface and the anomalies identified both by geophysical surveys and aerial photographs. GPR and GM data reveal a probable regular system based on rectangular lots. This pattern can be dated by excavations at least at the second half of the first century BC, when the ceramic workshop is working. However, it cannot be

Fig. 11 Interpreted depth slices with identification of the most interesting archaeological features (black dashed lines) that potentially characterize the site

excluded that the regular system can go back to a previous phase, given the pre-existence of the excavated road. For the latter, as already noted (Santoriello 2017), the chronology at the end of the fourth–beginnings of the third century BC, the particular size and the probable function as a centurial axis characterize it as a road of considerable importance, built around the period in which the colony of Beneventum was established. The correspondence between the relevant settlement of Masseria Grasso, the path of the main road and the information retrieved from seventeenth-century toponymy, which returns the name Recerola for the investigated area—probable degradation of the oldest Nuceriola, settlement mentioned on the Tabula Peutingeriana at four Roman milia from Beneventum (De Vita and Terribile 2014)—suggest to recognize a section of the Appian Way, as already hypothesized by Meomartini (1907). Therefore, the important position of the site in relation to the ancient rural framework could lead to identify the site as the ancient Nuceriola (Fig. 12). The complexity of the structures and the long lifespan of the settlement is yet an aspect to explore and clarify in order to understand the real function of the site in the context of ancient settlement dynamics. Future excavations will interest the alignments identified with GPR that seem to suggest the eastern edge of the excavated building. It will thus be possible to complete the excavation of the productive complex and to understand its relations with the wider settlement organization.

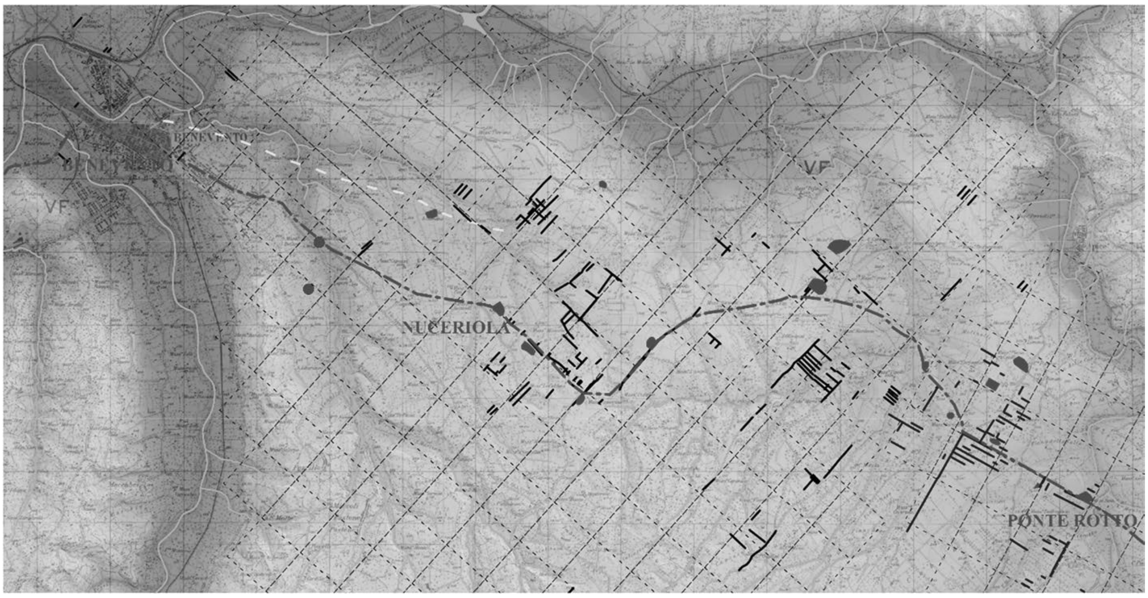

Fig. 12 Reconstruction of the rural framework east of *Beneventum*, imperial age

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Author Contributions ER, LC, GDM and FP carried out the geophysical measurements (Geomagnetic and GPR), processed and analysed the data. AS (AAL Project Leader), CBDV and DM carried out the archaeological studies, the excavations and the interpretation of the geomagnetic maps.

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