2025 IMEKO TC26 International Conference on
Metrology for Archaeology and Cultural Heritage
Bergamo, Italy, October 15-17, 2025

ERT surveys at the Necropolis of Baucina (Palermo)

Lara De Giorgi[1], Dora Francesca Barbolla[1], Giovanni Leucci[1]

[1] *Institute of Cultural Heritage Sciences (ISPC-CNR), prov.le Lecce-Monteroni, 73100 Lecce (Italy), giovanni.leucci@cnr.it*

Abstract. **The archaeological site of Monte Carrozza and Monte Falcone dominates in the south and east of the modern town of Baucina. These are two reliefs of modest size, separated by a small hill elongated in an East-West direction where the cliffs stand the necropolis. On these hills, probably in the sixth century. B.C., settled people, *sicane* that at the end of the century came into contact with the Greek colonies of Himera and the Punic Soluntum, as the research conducted in the last decade have demonstrated. Located in the hinterland, on the watershed between the river San Leonardo and Milicia, the sites are located in a critical point, in an area open to the connections between Palermo, Solunto and Himera. Archaeological excavations are conducted by the Chair of Ancient Topography of the University of Palermo, in agreement and cooperation with the Superintendence of Cultural Heritage of Palermo and with the logistical and financial support of the City of Baucina. Investigations affecting a sector of the cemetery located along the southern slope of Monte Falcone to combat the phenomenon of illegal excavations. For this purpose were undertaken, a series of geophysical surveys were. The survey results showed the presence of various structures, likely archaeological interest. Subsequent excavations made in areas investigated by geophysics have unearthed different funerary structures: burials in graves or nasturtium, cremation within pithoi or amphorae. The dead were accompanied by grave goods of the Greek tradition: skyphoi, achromatic cups, etc. Particular interest is a large tomb in an artificial cave entrance that consists of pillars and lintel plaster. The grave diggers violated by poachers is unique for their monumental architecture. It was reached by a corridor carved in the rock, in whose landfilling and numerous ceramic fragments were recovered a bronze coin.**

1. Introduction

In 1991, the Superintendency of Cultural and Environmental Heritage of Palermo accepted the Municipal Council of Baucina to insert the area between Monte Falcone and Monte Carrozza (Fig. 1a) among the regions subject to archaeological constraints. At the same time as this request, he undertook an excavation campaign that involved a sector of the cemetery (already excavated in the 1970s) and a sector of the town of Monte Falcone. Part of the finds from this excavation campaign is currently on display, together with objects seized by the Carabinieri from local "grave robbers" in the Civic Museum of Baucina (Archaeological Antiquarium). The location of this settlement is strategic: it is located on the watershed between the Milicia River and the San Leonardo River basin, and from the finds, it is possible to highlight the presence of commercial and political relations with both the Phoenician-Punic colonies of Palermo and Solunto both with the Greek polis of Himera and Akragas. On the surface of these small reliefs, the remains of ancient structures and numerous terracotta artefacts emerge, including tiles, amphorae, black-painted ceramics and loom weights. The necropolis is located partly in correspondence with the limestone crags of Monte Falcone and partly in the limestone crags of the hill interposed between the two residential centres of Monte Falcone and Monte Carrozza the latter probably belonging to both inhabited areas. Over the years, the necropolis has been subjected to numerous looting, which has changed its original appearance. Near the cave tombs, there are often numerous mounds of earth as evidence of the "grave robbers" activity. Following the archaeological excavation in 1991 and the subsequent surveys and studies conducted by the archaeologist Dr G. Bordonaro [2], the presence of pit tombs interspersed with capuchin and enchytrismòs burials, by cremations and by artificial cave tombs emerged. . The latter, still visible today, housed multiple burials accompanied by grave goods consisting of Greek and indigenous pottery and were closed by gypsum plates from the nearby Balatelle district. The existence of the inhabited nucleus of Monte Falcone is highlighted by the presence of possible wall structures, indicated by alignments of rocks located on the southern slope; the inhabited area of Monte Carrozza, on the other hand, is evidenced by the discovery of square slabs

and stones presumably used in the construction of buildings. A prehistoric phase is also documented on both reliefs, as evidenced by the obsidian tools from Pantelleria and broken fragments of monochrome red pottery attributable to the Copper Age. Traces of frequentation in the Byzantine and Arab ages are present, however, only in Monte Falcone. A campaign of geophysical measurements was undertaken to carry out targeted excavations and therefore re-evaluating the precious archaeological site. It should be emphasized that the archaeological sites in question have never been investigated with indirect investigation methodologies and have never been studied to their full extent. The use of geophysical prospecting, therefore, had the objective of mapping the archaeological elements still buried and presumably not violated by the "grave robbers", at the same time allowing targeted and productive archaeological excavation operations, as well as the accurate description of the extent and methods areal development of the settlement.

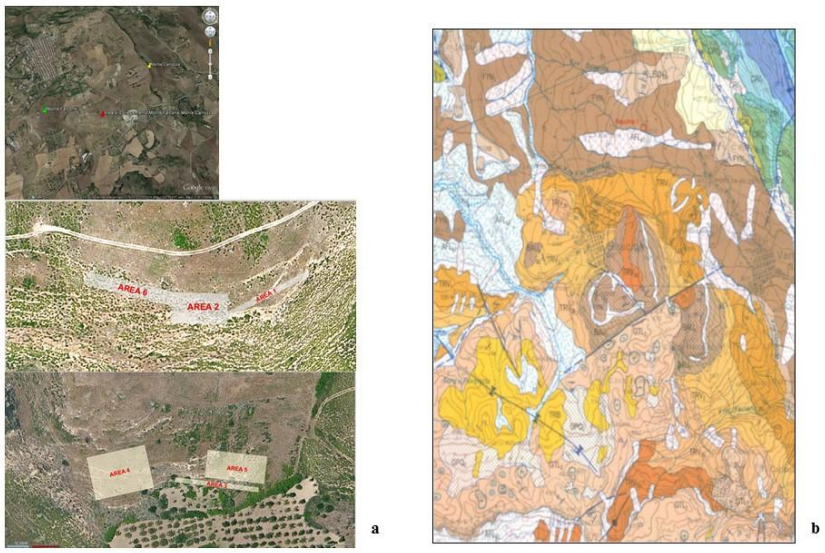

Figure 1. *a) Location of the survey areas; b) Extract from Sheet 608 "Caccamo" in scale 1: 50.000 ([3])*

2. Geological Setting

The area in which the archaeological sites of Monte Falcone and Monte Carrozza fall is located in the territory of the Municipality of Baucina (Palermo), which from a cartographic point of view is included in the 1: 25000 scale tablets "Ciminna" [4] and "Ventimiglia di Sicilia" [5] published by the Italian Military Geographical Institute (Fig. 1b). The area under study is located at an altitude range between 580 and 740 m a.s.l. and has a morphology that strictly depends on the lithology of the outcropping formations and the interaction with the local hydrological, climatic characteristics.

In this high hilly area, the Miocene biocalcarenite soils of the Baucina Formation and the Quaternary overwriting of the large-block groundwater deposit dominate. The presence of vegetation cover in these soils varies with the seasons, but the dominance of bushes and shrubs is almost always noted. In the sites of Monte Falcone and Monte Carrozza, where there are lithoid outcrops (calcareous, conglomeratic or quartz arenite), the terrain's morphology is harsh, with rugged and sometimes sub-vertical slopes that often give rise to landslide phenomena of collapse. On the other hand, in correspondence with the predominantly clayey-sandy outcrops, the soil shows less steepness and the prevalent landslide phenomenologies, described in the P.A.I. [1], these are slow flows, widespread landslides, complex landslides and, to a lesser extent, the phenomena of accelerated erosion, soliflux and sliding. From the hydrological point of view, the neighbouring area is affected by the Acquasanta and Margio streams. The hydrological regime is purely torrent, and surface outflows are limited to short periods of the year, during the rainy season and in conjunction with

intense and concentrated rainfall. From a geological point of view [3], the two reliefs consist of the following Miocene formations, from bottom to top (Fig. 1b): Terravecchia Formation (Upper Tortonian - Lower Messinian): these are conglomerates and coarse sands, sandy pelites, pelitic sands and sandstones, sandy clays and pelites, grey or bluish marl with calcareous plankton. They are of fluvial-delta environment up to an open platform. The lower limit is not consistent with the oldest soils. In particular, the following members are present: Pelitic-clayey member (TRV3): grey marls, grey-greenish or bluish clays (TRV3b) with planktonic foraminifera (biozone at Globorotalia *suterae* and Globorotalia *conomiozea*) and calcareous nannofossils (biozone from Minilytha convallis to Reticulofenestra marine TR3 and fossil *marne rotaria*)) to Turborotalia *multiloba* (non-distinctive area). These deposits rest in part conformity or heteropy on (TRV2) and are of a *prodelta* environment.

3. Geophysical data acquisition and analysis

The land conditions to be investigated related to the steep slope, the roughness, the tall grass, the presence of numerous obstacles (stones, trees, vineyards, etc.) have strongly influenced the choice of geophysical methodology. Therefore the geoelectric method was used in the measurement campaign. This methodology allows characterizing the subsoil from the point of view of the physical parameter electrical resistivity (ρ). The geoelectric method of resistivity is based on the circulation of stationary electric current (continuous or very low frequency, so that induction phenomena are negligible) in the subsoil. The material means respond to a current flow differently, based on the value assumed by the physical parameter of resistivity. Typically, the resistivity that lithotypes offer to the circulation of electric current depends on the interstitial water content, the temperature, the content of dissolved gases in the water, the presence of free ions. The resistivity values are estimated using an electric quadripole consisting of two electrodes A and B, called current electrodes, and two M and N electrodes called potential electrodes. A current of known intensity I is sent underground through electrodes A and B and the potential difference ΔV is measured through electrodes M and N. The four electrodes together constitute the electrode measuring device, which can have different geometries of arrangement on the ground, each characterized by a parameter K which takes the name of "geometric factor". The relationship that binds the physical parameters electric current (I), potential difference (ΔV), electric resistivity (ρ) is the well-known Ohm's law:

$$\rho = K\,\Delta V/I.$$

By defining ΔV in volts, I in Amperes and K in meters, the resistivity ρ is expressed in Ohm m. In reality, what is calculated is an apparent resistivity (ρ_a); that is, it is a resistivity value due to the different contributions of the whole subsoil that will be felt, more or less strongly, depending on the distance from the measuring device. The Abem georesistivimeter with 64 active channels was used for the measurements. The maximum length of the profiles was chosen based on the maximum depth of interest (the first meters from the ground level) and the probable resolution required. Therefore, a variable number of electrodes were used, and inter-electrode distance was also variable and adapted to the particular case study. The dipole-dipole electrode device was therefore used [6]. The disposition of the electrodes was that which allowed, through a specific field procedure, to obtain a regular grid with the interelectrode distance varying between 1 and 4m. Acquisition geometry was therefore used, which provides for the arrangement on the ground of a serpentine power line that allows for an increase in data density. Thus, from this dataset, it is possible to extract both Vertical X.Z. (TGV) and Horizontal X.Y. (T.G.O.) Geoelectric Tomographies at various depths give a clear picture of the resistivity distribution in the subsurface. For the data inversion, the ERTLab software (http://www.geostudiastier.it/) was used, using a finite element algorithm to model the terrain topography accurately. The data relating to the areas found to be the most interesting and which, following the results of the geophysical surveys, have been excavated are commented on below. For area 2 (Fig. 1a), the electrical resistivity distribution patterns at various depths are shown in Fig. 2a

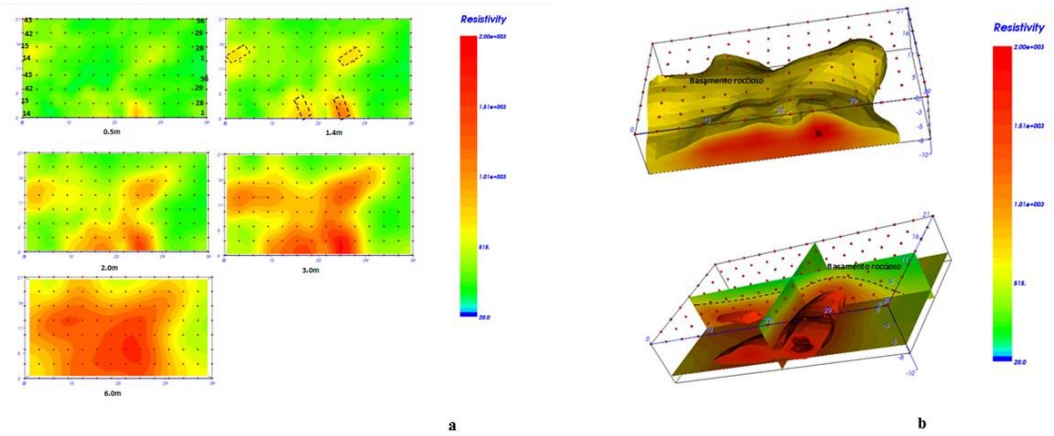

Figure 2. a) 3D model of resistivity distribution at depths between 0.5 and 6m; b) Isosurfaces of resistivity

From the resistivity distribution model (Fig. 2a), the presence of a heterogeneous subsoil with resistivity values between 50 and 2000 ohm m is evident. In particular, we note the presence: 1) areas (in red), indicated in the black dotted boxes, with resistivity values between 1800 and 2000 ohm m; these values indicate the probable presence of areas in which a resistivity values between 50 and 180-ohm m; these values indicate the probable presence of topsoil material; 3) areas related to the bedrock at depths between 3.0 and 6.0m. The resistivity data were also represented in isosurfaces (Fig. 2b). The course of possible structure of archaeological interest is located. The relatively low resistivity values suggest that these anomalies are not attributable to the presence of voids but too inconsistent materials within which there are small voids; 2) areas (in green) with

the rocky base and the structures of probable archaeological interest are better highlighted in it. For area 5 (Fig. 1a), the electrical resistivity distribution patterns at various depths are shown in Fig. 3a

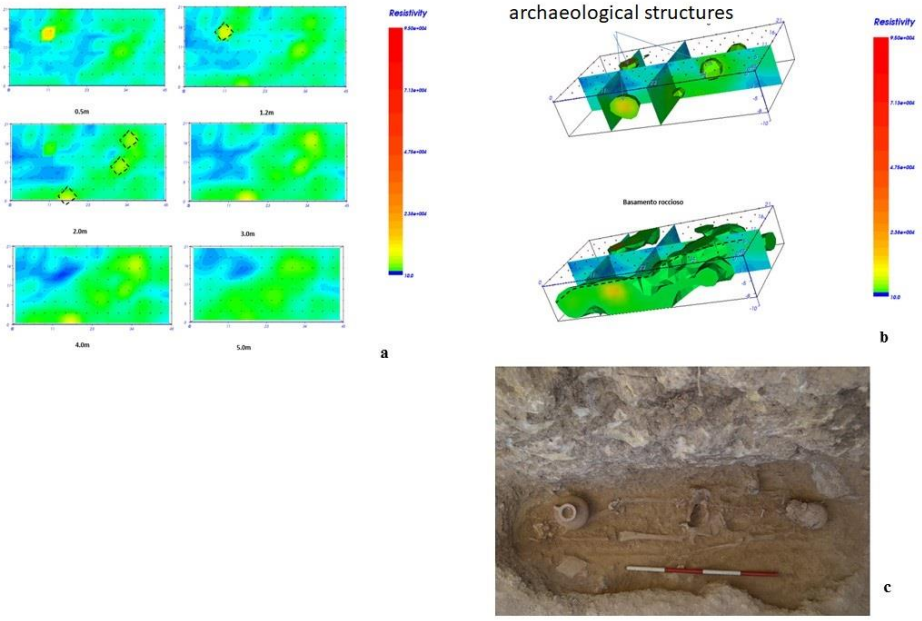

Figure 3. Area 5: a) 3D model of resistivity distribution at depths between 0.5 and 6m; b) Isosurfaces of resistivity; c) photo of the tomb excavated after the result of the 3D electrical survey

Also, in this case, from the resistivity distribution model (Fig. 3a), the presence of a heterogeneous subsoil with resistivity values between 50 and 90000-ohm m is evident. In particular, we note the presence: 4) areas (in yellow), indicated in the black dotted boxes, with resistivity values between 1800 and 2300 ohm m; these values indicate the probable presence of areas in which a possible structure of archaeological interest is located. The relatively low resistivity values suggest that these anomalies are not attributable to the presence of voids but too inconsistent materials within which there are small voids; 5) areas (in blue) with resistivity values between 50 and 180-ohm m; these values indicate the probable presence of topsoil material; 6) areas related to the bedrock at depths between 3.0 and 6.0m. The resistivity data were also represented in isosurfaces (Fig. 3b). The trend of the rocky base and the structures of probable archaeological interest are better highlighted in it.

4. Conclusions

In July 2014, archaeological investigations began in a sector of the necropolis located along the southern slope of Monte Falcone to combat the phenomenon of clandestine excavations. The research was conducted by the Chair of Ancient Topography of the University of Palermo, in agreement and collaboration with the Superintendence of Cultural Heritage of Palermo and with the logistical and financial support of the Municipality of Baucina. In consideration of the results of the geoelectric survey for the excavation, air five was chosen. In this area, anomalies attributable to the probable presence of underground tombs were identified. Also, the choice to operate in area 5 arose above all from the possibility of exploring a large chamber tomb partially violated by clandestine excavations. The burial kept the entrance portal in good condition, while in the filling earth, in addition to human bones, numerous fragments of grave goods were still present.

Furthermore, the tomographies indicated two significant traces on the sides of this tomb. Digging began in the lower part of the area where the result of the electrical tomography stated the presence of an anomaly (Fig. 3a). The excavation revealed a first burial within tiles. The excavation subsequently revealed a second cave tomb. It is a small structure. Another type of tomb attested during the excavation is enchytrismòs: 4 burials have been identified, three of which are located in the lower crag and only one in the upper one. For one of the burials, the use of a Punic amphora is noted. None of the enchytrismòs tombs presented any equipment (Fig. 3c).

References

[1] Assessorato Territorio e Ambiente Regione Siciliana, 2010 – I Aggiornamento del Piano Stralcio di Bacino per l'Assetto Idrogeologico: Bacino Idrografico del Fiume Milicia (n. 035), Area territoriale tra il Bacino del F. S. Leonardo e il Bacino del F. Milicia (034), Area territoriale tra il Bacino del F. Milicia e il Bacino del F. Eleuterio (036). http://www.sitr.regione.sicilia.it.

[2] Bordonaro G., 2011 – Monte Falcone e Monte Carrozza. Un insediamento indigeno al confine tra il mondo fenicio-punico e quello greco. Forma Urbis XVI, 10: 40-48.

[3] ISPRA (Servizio geologico d'Italia), 2010 – Carta Geologica d'Italia: Foglio 608 "Caccamo", 1:50.000. Nadir S.a.s. di Antonio D'argenio, Palermo.

[4] Istituto Geografico Militare Italiano – Foglio 259, IV, SO "Ciminna", 1:25.000.

[5] Istituto Geografico Militare Italiano – Foglio 259, IV, NO "Ventimiglia di Sicilia", 1:25.000.

[6] Loke, M. H.: Electrical imaging surveys for environmental and engineering studies, A practical guide to 2-D and 3-D surveys: RES2DINV Manual, IRIS Instruments, www.iris-instruments.com, 2001.