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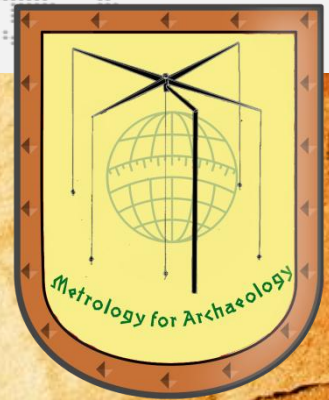
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I<sup>st</sup> International Conference on

# Metrology for Archaeology



## PROCEEDINGS

### VOLUME I



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# Arpi: measure the forms of an Italiote city (4<sup>th</sup> – 2<sup>nd</sup> centuries BC)

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**Abstract** – The settlement of Arpi (Foggia, Apulia), ca. 1000 hectares of extension, was occupied from Protohistory to the Roman period, thus comprising main difficulties in terms of knowledge, protection and control of the territory as well as problems in archaeological diagnostic. Therefore, a major project was launched for the reassessment of previous data and for new geo-environmental analysis. We intend to present the first geophysical applications on a sample of inhabited multilayered and complex building types (since the archaic period the technique of construction with raw earth was the most often used).

In “Arpi archaeological project”, geomagnetic and ground penetrating radar were carried out in order to highlight buried structures.

## I. INTRODUCTION

The establishment of Arpi, at 8 km northeast of Foggia, is located in the alluvial plain of the Tavoliere of Puglia. It occupied a strategic position halfway between sub-Apennine mountains and the coast, and near a navigable river, the Celone, which, with the Candelaro river, provided access to the sea, to the south of the current Siponte. The current landscape retains few traces of ancient establishments.

Arpi played a leading role over the centuries in the historical landscape of ancient Daunia. The developed programs and the research conducted for more than two decades by Marina Mazzei, of the Archaeological Superintendence of Puglia, have profoundly renewed knowledge of this Daunian settlement [1].

Since 2014, a new program on the forms of the city, is coordinated jointly by the Centre Jean Bérard (USR 3133, CNRS - EFR) and the Department of Cultural Heritage of the University of Salerno, in collaboration with the Center for Daunian archeology of the Superintendence of Puglia, the Department of Biosciences and Territory of the University of Molise and the Institute of Methodologies for Environmental Analysis, CNR-IMAA (Tito Scalo) [2]. Research focuses on the articulation, the

relationships and the functions of space in the long run; by the means of a multidisciplinary approach, we intend to provide a global overview of the territory for a better knowledge and protection of a cultural heritage of enormous dimensions, which is continuously violated.

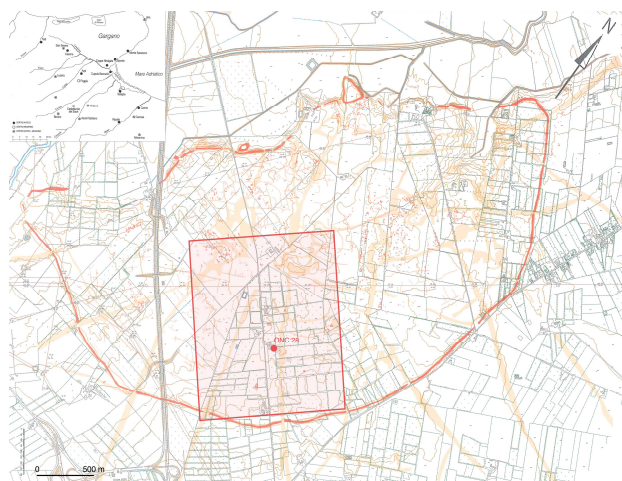


Fig. 1. Plan of Arpi with indication of the “Montarozzi” zone and the ONC 28 (Reelaboration by G. Chapelin, Centre Jean Bérard, after Guaitoli 2003, fig. 352, p. 190 and Mazzei 2010, p. 10).

## II. METHODOLOGY

The project includes two main operational axes. The first aim is to produce an integrated system of knowledge of archaeological and geo-environmental data. The system integrates the verified, formalized and aggregated information, including already existing data as well as what is produced by the in-progress research. All is collected in a unique, standardized, and GIS-oriented information system. Structuring and managing information by levels provide a basis on which it is possible to program the archaeological diagnostic as well as topographical and archaeological study.

The second aim of the program is the study of a specific

sector of the city, the Hellenistic aristocratic houses of the Montarozzi area, located in the south-east area, bounded by the ancient walls of the city, the *aggere*. The analysis includes evidence excavated and published in the past ("peristyle house" partly brought to light in 1953, the house known as the "mosaic of griffins and panthers" ONC 28 excavated in the 90's, etc.) as well as new and unpublished material.

The study will provide clarification of the phases of occupation and abandon inasmuch as to deal with the organization of space, the axes of circulation and relations between the houses, sacred areas and the necropolis contexts.

The research is completed with in-the-field analysis, carried out with archaeological field-walking, geomorphological and archeomorphological survey integrated with geophysical surveys.

The most suitable geophysical investigation techniques employed for archaeological purposes are the geomagnetic, GPR and resistivity/conductivity (DC and EM) methods. These techniques are not invasive and allow us to obtain high-resolution images of subsurface, even if their use is dependent on site and resolution. In general, the geomagnetic and EM are more adaptive for large surveys, in order to obtain relative fast results with low resolution. On the other hand, involving heavy data process, GPR show high-resolution information but it is more adapted for small survey areas. In this perspective, the integration of different geophysical methods was largely used in archeogeophysical investigations in order to detect buried remains. Each geophysical technique has the ability to define a physical parameter, which enables highlighting some patterns of the hidden, buried object [3] [4]. However, the geophysical contrast between archaeological features and surrounding soils are sometimes difficult to define due to problems of sensitivity and resolution, both related to the characteristics of the subsoil and the geophysical methods. Therefore, the use of geophysical methods should be careful and aware.

### III. ARCHAEOLOGICAL CONTEXT

The early stages of the research concerned the study of the area called ONC28, where lies the *domus* known as of "the lions and panthers" which, in the second half of the third century, marks the strong socio-cultural change that took place in the Montarozzi area, occupied in previous phases with funeral and housing or worship contexts.

The discovery of the mosaic representing lions and panthers that gave its name to the *domus* occurred in 1992, during work on the irrigation systems performed by the *Consorzio di Bonifica di Capitanata*. It was then followed by excavations conducted in 1994, 1995 and 1997 under the direction of Marina Mazzei.

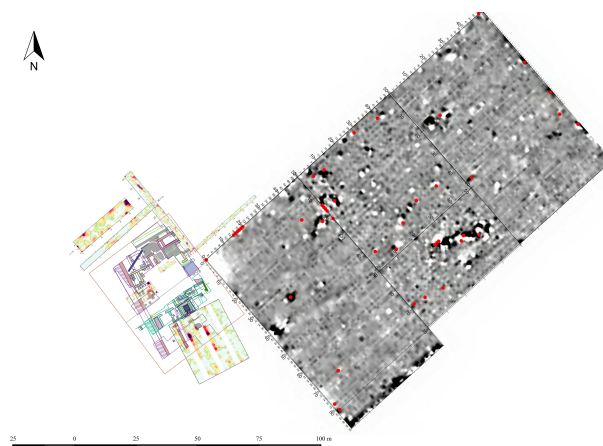


Fig. 2. Schematic plan of the ONC 28 with the archeogeophysical investigations (Elaboration by V. Soldani, Centro Operativo per l'Archeologia della Daunia, Soprintendenza Archeologia della Puglia, and A. Terribile, Università degli Studi di Salerno).

In her many publications, the scholar pointed out the special features of this large dwelling that answers precise needs of life and representation of an aristocratic family at Arpi in the second half of the Third century BC. The resumption of the study of the evidence brought to light, from the excavation documentation to the material culture unearthed, has allowed us to sharpen the stratigraphic palimpsest and to give a more accurate chronological sequence, proposing a new subdivision in phases for the use of the area.

The stratigraphy at the ONC28 has a variable thickness of about 1.50 to 2.00 m between the actual ground level and the natural soil characterized by lenses and / or layers of caliche (calcrete or carbonate crusts). The thickness of the lenses and / or layers of caliche (calcrete or carbonate crusts) vary from a few centimeters up to about 5 meters. An early form of occupation may be identified with some structures in raw clay, situated in the northwest corner of the investigated area, probably dating to the Fifth century. The walls were built directly on top of the carbonate crust. The structures appeared east of a gap in altitude constituted by rising the circulation level on which, probably already at this phase, runs a well-trod road oriented north-south that borders the area to the west. Unfortunately the function of this first complex is uncertain.

Between the end of the Fifth and the middle of the Fourth century, the area change destination and becomes a funerary space, as evidenced by the twenty grave-pits excavated between 1992 and 1997. In general, those graves were dug into the limestone bench (the so-called "crusta" or carbonate crust) with uniform orientation NW/SE, presenting deceased buried in a crouched position and furniture placed around the head or feet. The tombs, when not stolen in ancient times, retain the cover

slabs of limestone.

During the second half of the Fourth century, the area undergoes transformations and new structures are placed to the east of the north-south road. In connection with the new buildings, is constructed in terracotta an important channel system used to collect and convey wastewater. The walls are also in this case constructed in clay with coatings of coarse plaster and thick layers of limestone powder typically compose the soils. At present, it is still difficult to affirm whether the site was only one large building or different units, as well as unclear is the intended use of the facilities.

In the last quarter of the Fourth century, the area is abandoned. The abandonment of the structures is accompanied by a ritual documented with at least two votive deposits. Almost at the same time or shortly thereafter, some areas are occupied by new burials.

During the second half of the Third century, probably in the last decades, a large *domus* is built partially covering the existing building structures that seem to have undergone significant transformations over time. The planimetric articulation and its decorative system on its walls and floor qualify the high social level of its inhabitants.

The *domus* is bounded to the west by the north-south route and to the north by a second axis of dirt route oriented east-west. Four areas of the house were recognized. The masonry technique in raw clay continues to be predominantly used. All the walls showed coatings of plaster, either in structural style made with plaster and stucco or simply plain white. Some of the rooms still had the mosaic floors or received a more simple coating of “plaster”. Only rarely, the walls had bases of foundation made in stones with the elevation in clay.

During the first half of the Second century, the area experienced a new period of change. During this phase, the rooms of the residence and the representation spaces of the *domus* undergone several transformations. In different rooms the “plastered” pavements were removed, while the mosaics remained in place; some accesses were obliterated and new spaces of passage between rooms were created.

In the second half of the Second century, the *domus* at the ONC28 is completely abandoned.

So far, an area of about 780 square meters of the *domus* of lions and panthers has been explored, which is only a part of its original extension. Whereas to the north and west the area is bordered by two dirt roads, the eastern and southern limits are not known. It should be noted the state of damages, done by agricultural interventions and by the occupation of the central body of the dwelling by a shed.

The excavations took place over several years and were conducted under conditions of the utmost urgency. Today the area, in private ownership, is completely covered.

A first campaign of geomagnetic and geo-radar surveys

allowed the creation of a hypothesis for the development plan of the *domus* and its inclusion in a broader context. It also permitted to calibrate the validity of geophysical methods, in relation to the geological stratification and to the remarkable complexity and overlap of materials and construction techniques adopted.

#### IV. GEOPHYSICAL METHODS AND RESULTS

Therefore, in order to highlight the buried archaeological features at Arpi, large magnetometer map and 3D-GPR analysis were carried out. The magnetometer approach allowed us the possibility to obtain a fast and large investigation on the studied area with a short-time consuming and a high-detection check. The magnetic measurements were performed using an optical pumping magnetometer G-858 (by Geometrics) in gradiometric configuration, with two magnetic probes set in a vertical direction (1m each other). The large magnetic map was obtained by several parallel profiles with an interspaced line of 1m and a sampling rate of 5Hz. The rough magnetic data were filtered to obtain the best S/N ratio providing pass-band filter, spikes elimination, zigzag effect and destripe. The data were further processed using a kringing interpolation and visualized as a shaded relief image [3] [4]. One of the geomagnetic elaborated maps is visible in figure 3. The map highlights several linear anomalies (yellow arrows), which should be associated to archaeological linear features. Moreover, the large geomagnetic anomaly (red circle) should be associated to a tomb, which was highlighted in the past. Other similar anomalies in the area could be interpreted in the same direction.

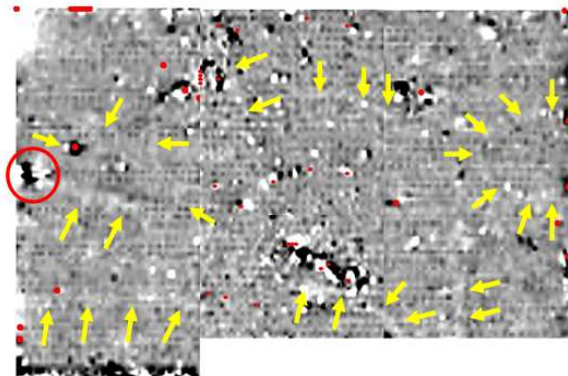


Fig. 3. Interpreted Geomagnetic map.

The GPR is an electromagnetic (e.m) method used for archaeological targets. The GPR radiates short e.m. pulses into the ground and detects the signals reflected from subsurface structures. In order to investigate some areas, the GPR measurements were performed by the means of the SIR3000 instrument (GSSI), which was connected to a monostatic antenna (400 MHz, GSSI). The ReflexW software was used to process the data. The employed process was: dewow, gain, static correction,

bandpass frequency, background removal, average filter. Moreover, an estimation of the electromagnetic velocity and a migration tool was applied on the radargramms ( $V_{em}=0.09$  m/ns). In order to observe the archaeological geometry of buried structures, a 3D-GPR approach was adopted. Similar anomalies with the same geometry and the same depth were found in some other areas investigated (fig. 2).

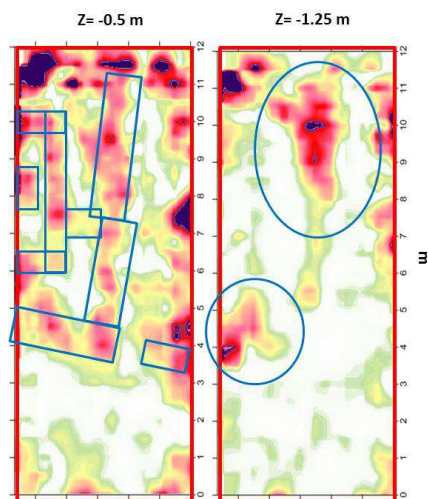


Fig. 4. GPR time slice.  $V_{em}= 0.09$  m/ns

The GPR profiles were carried out along parallel lines on both directions with an interpolation line of 0.5m. Figure 4 shows two time slices coming from a 3D-GPR. It shows a large and well-defined reflection zone at about 0.5m and 1.25m deep, which should be associated to buried archaeological structure (walls, cavity, etc.).

#### IV - CONCLUSION

Today, except for the Medusa's tomb (Ipogeo della Medusa), almost nothing is visible of the ancient establishment. The area delimited by the city walls (*aggere*) is still private land and it is systematically subject to clandestine excavations. The integrated use of different geophysical technologies shows the importance of multisensor data set [3] [4], which can significantly contribute to provide data useful for the archaeological excavations and to improve the archaeological plan of the already excavated structures (walls, tombs, etc.).



Fig. 5. Sector excavated in 1994 and recently analyzed with the GPR (Photo M. Marchesino, Centro Operativo per l'Archeologia della Daunia, Soprintendenza Archeologia della Puglia).

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