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Geophysical survey at the coastal tower of S. Caterina (Lecce, Italy)

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***Abstract* – The Santa Caterina tower in Nardò (Lecce, Italy) represents one of the many types of coastal towers of the ancient Terra d'Otranto province. It was part of the defensive system of the Ionian coast of Salento against the Turkish threat. The integrated geophysical prospections are part of the analysis of the tower about constructive elements, wall discontinuities, functional modification in order to understand the phases and the change of the structure over the centuries. The information collected will be useful for a restoration project finalized to recover a building abandoned for years.**

I. INTRODUCTION

This paper presents the results achieved to plan a restoration and a requalification project of the coastal tower of Santa Caterina, located in the natural park of Santa Caterina al Bagno in Nardò (Lecce, South of Italy) (fig. 1). The tower represents one of the many types of coastal defensive structure of the ancient province of Terra d'Otranto along the Ionian coast from Nardò to Porto Cesareo against the Turkish threat [1]. It is one of the eight towers of the Nardò series [2]. Thanks to its position, placed on a promontory at about 51 m above sea level, and to the large dimensions, it is one of the most spectacular and eminent well preserved defensive fortification [3].

Ground-Penetrating Radar (GPR) and Electrical Resistivity Tomography (ERT) were undertaken inside and outside of the tower in order to obtain information about the structural conservation state of tower.

Results indicate that the integrated studies were fundamental to plan a correct recovery project which aims to preserve and enhance the architectural integrity of a historic monument.

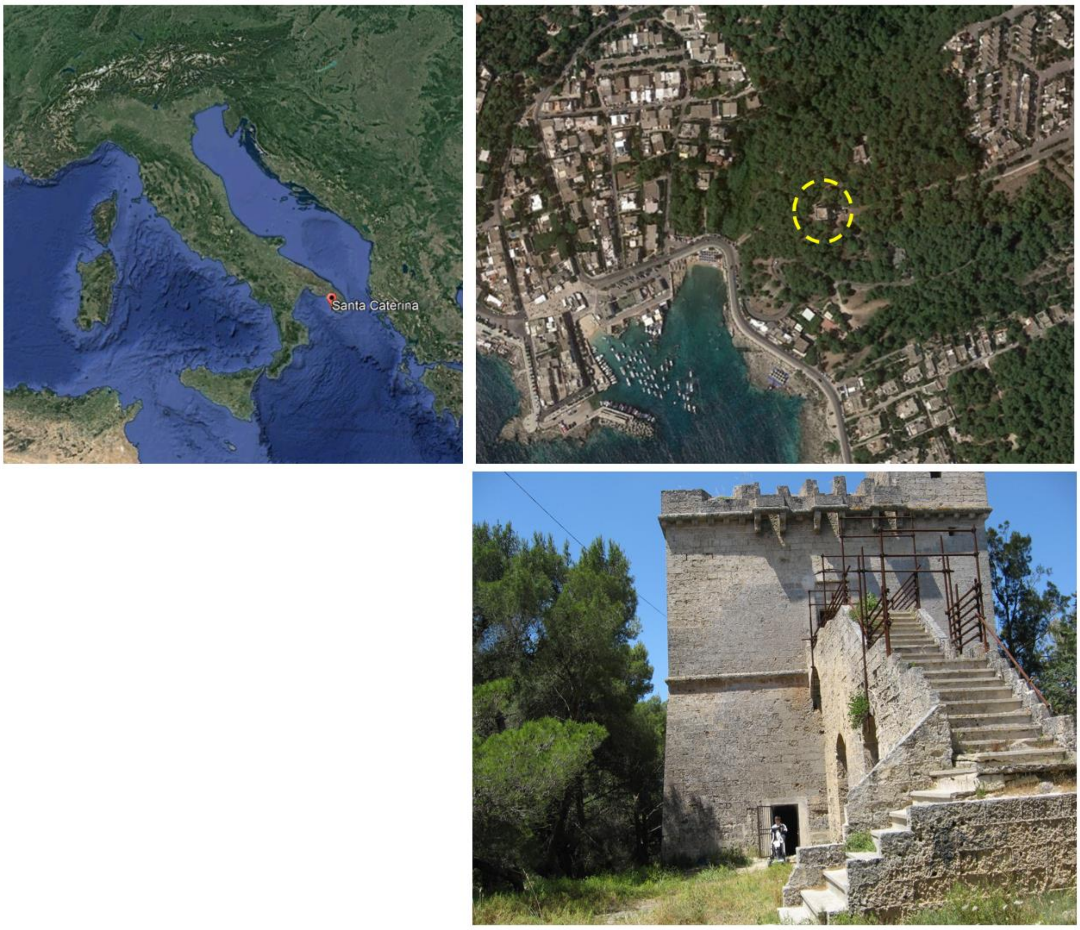

Fig. 1. The tower location

II. GEOPHYSICAL DATA ACQUISITION AND ANALYSIS

ERT data were acquired with a Syscal-kid Resistivitymeter (manufactured by the Iris Instruments), in multielectrode configuration. Resistivity field data were collected using 24 electrodes with 1.5m spacing. The selection for electrode arrays was dipole-dipole. The dipole-dipole array is very sensitive to horizontal changes in resistivity, but relatively insensitive to vertical changes in the resistivity. This means that it is good in mapping vertical structures, such as voids, but relatively poor in mapping horizontal structures [4]. The above described electrodes array allows one to investigate, with a good resolution, the shallow 3m of subsoil [5, 6]. The measured data were processed by means of 2-D inverse modelling software, applying Loke and Barker inversion methods. The software employs a quasi- Newton technique to reduce the numerical calculations [7]. It produces a 2-D resistivity model satisfying measured data in the form of a pseudosection. The goodness of the fit is expressed in terms of the relative RMS error. This method is more suitable where both strong lateral resistivity variations and depth changes occur and in complex geological models such as in a karstic area [5, 6].

For the ERT profile acquired in the area outside the tower results shows (Fig. 2) a layered resistivity profile in the top 3.0 m. Is clearly visible a zone of high resistivity (about 15000 to 20000 ohm m) labelled C. This anomaly is 1m depth and could be related to the presence of a cavity.

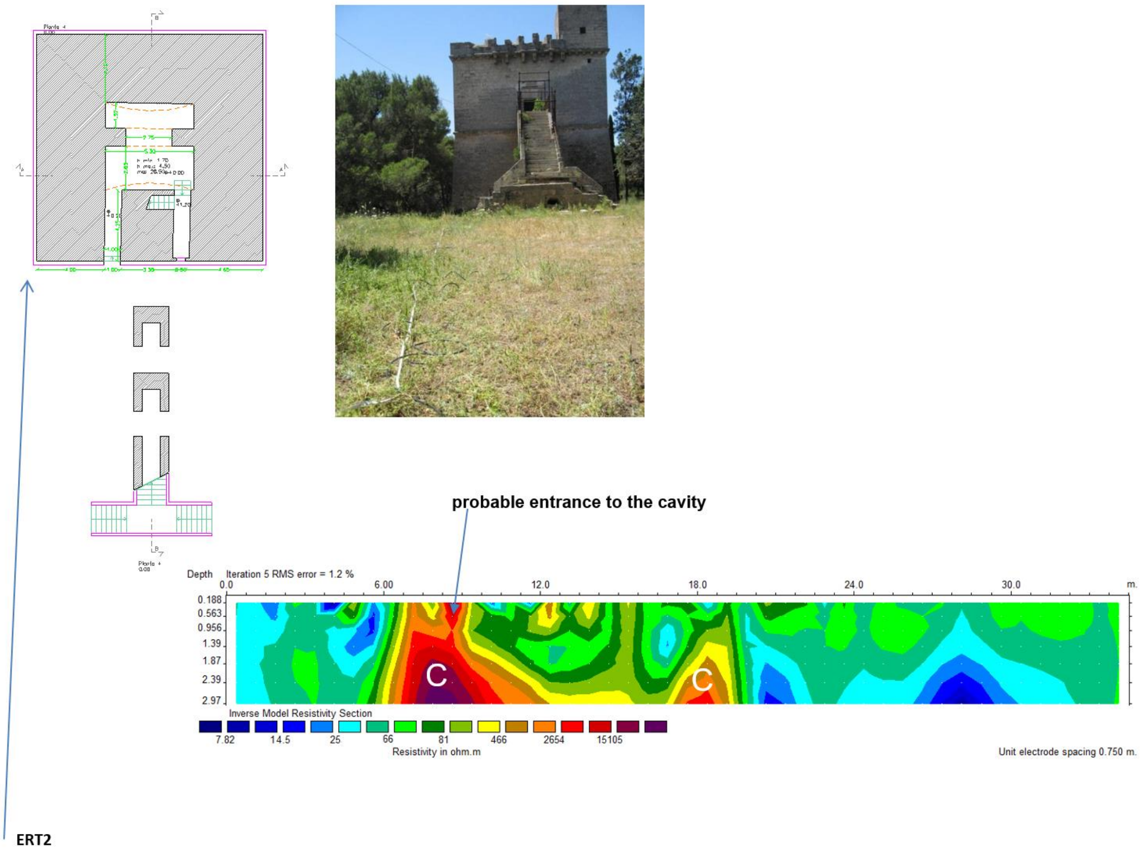

Fig. 2. The 2D resistivity distribution

The GPR survey was performed, with IDS Hi Mod georadar system. A dual band 200–600 MHz centre frequency antennae was used. A map of GPR profiles is shown in Figure 3. The following acquisition parameters were selected: samples per scan, 512; recording time window, 60 ns for 600MHz antenna and 120 ns for 200MHz antenna; gain function, manual. The most crucial step in GPR data interpretation is studying and understanding in a general way the components of 2D reflection profiles and then the reflection profiles themselves [5, 6]. Only when these components are understood can other displays such as amplitude maps and isosurfaces be interpreted. Take into account that the GPR profiles were normalised for amplitude, had background removed and were migrated using a Kirchoff 2D method. In order to perform a 2D Kirchoff migration the electromagnetic (EM) wave velocity was determined from the reflection profiles acquired in continuous mode, using the characteristic hyperbolic shape of reflection from a point source [5]. This is a very common method of velocity estimation and it is based on the phenomenon that a small object reflects EM-waves in almost every direction. The general stratigraphy in all profiles shows an unconsolidated surface soil with many pebbles that produced point-source reflections, (Figure 3) that enable the EM wave velocity analysis to be performed. The processing and imaging software (Reflex) allows the interactive velocity adaptation of a diffraction or reflection hyperbola by calculating a hyperbola of defined velocity and width. The velocities are combined into a 2D model using a special interpolation method. The interpolation is performed as follows: all actual velocities are summed for every point in the x–t range, proportional to the square of their distance from the (x, t) point. This method provides only the average EM-wave velocity to the depth of the source-point reflector. This type of 2D velocity distribution may be used in the 2D migration processing step. Application of this method gives both vertical (in time, hence in depth) and lateral velocity variations from 0.08 m/ns to 0.12 m/ns. An average velocity of 0.10 m/ns was obtained over the survey area.

Figure 3 show the processed R1 and R2 profiles related to 600MHz antenna. The R2 profile is near the ERT profile.

In the depth ranging between 1.0m and 1.5 m, it is possible to identify a reflection events (C) that denote a change in the polarity of the EM reflected way. This could be related to the presence of a cavity [5, 6]. In the R2 profile this correspond with the high resistivity anomaly (C).

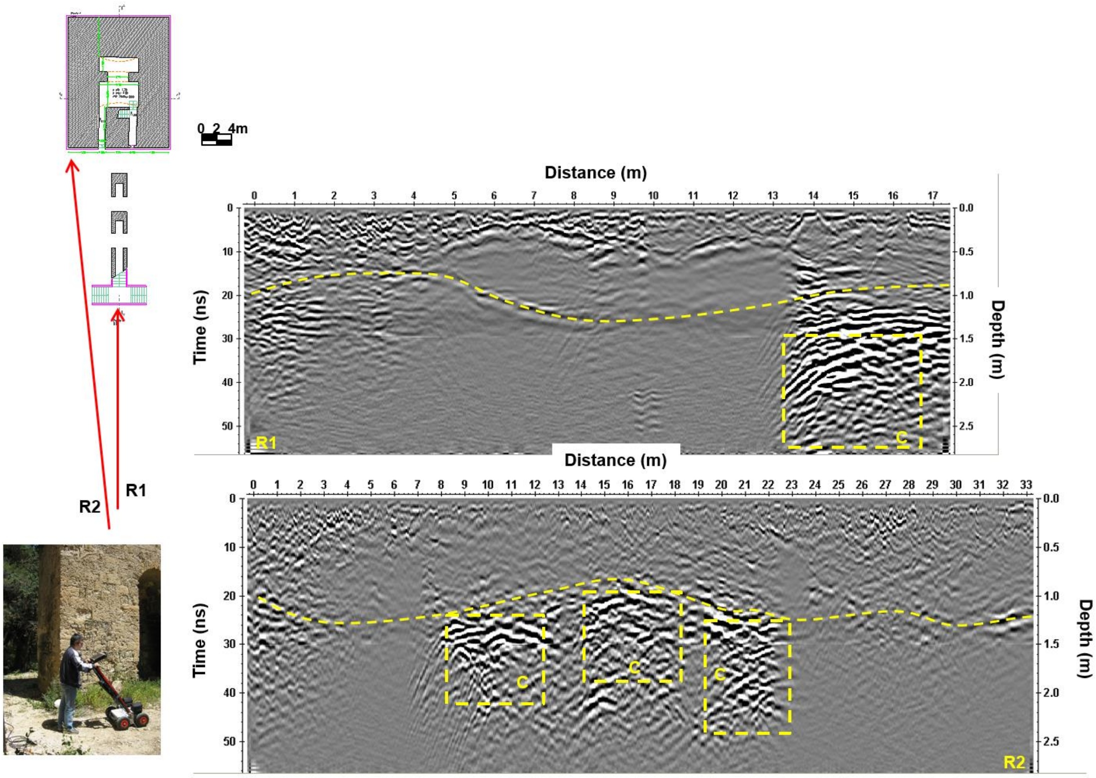

Fig. 3. The processed radar profiles

III. CONCLUSIONS

The first phase of this case study underline some interesting results.

The ERT profile highlighted the presence of a very fractured rocky substrate for the first 2m of depth.

The GPR profiles relating to the survey performed outside the tower show in the first meter from the surface the presence of significant disturbances to be related, probably, to the very fractured rocky substrate. The 2D ERT and GPR data acquired in the area outside the tower show the presence of an hypogean structure until now unknown.

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