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Geophysival investigations at the Cathedral of Catania

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***Abstract* – The Cathedral of Catania is a very important monument. It has been repeatedly destroyed and rebuilt after the earthquakes and volcanic eruptions that have followed over time. The first building dates back to the period 1078-1093 and was built on the ruins of the Achillian Baths dating back to the Romans, on the initiative of Count Roger, acquiring all the characteristics of an equipped (i.e. fortified) ecclesia. Already in 1169, a catastrophic earthquake demolished it almost completely, leaving only the apse part intact. In 1194 a fire created considerable damage and finally in 1693 the earthquake that hit the Val di Noto destroyed it almost completely.**
Geophysical measurements were undertaken inside and outside the Cathedral of Catania. In this paper some results related to ground penetrating radar (GPR) measurements are presented.

I. INTRODUCTION

Destroyed and rebuilt several times after natural events and accidents, the cathedral stands on the site of the Roman Achillian Baths and the martyrdom of the patron saint of the city.

The current church was built in 1711, on a project by Girolamo Palazzotto. The sumptuous facade in three orders by Giovan Battista Vaccarini is in white Carrara marble, adorned with columns and statues. Noteworthy are the central portal, with 32 finely carved wooden panels, and the three lava apses of Etna, a legacy of the previous Norman cathedral (Fig. 1).

Fig. 1. The facade of the cathedral

The interior, with a Latin cross plan, is divided into three naves. The frescoes by the Roman Giovan Battista Corradini stand out in the central apse, with the Coronation of Sant'Agata, while the two columns at the base of the apse arch and the single lancet window are of medieval origin. In the right nave there is the funeral monument of the musician Vincenzo Bellini, while in the right apse the sumptuous chapel of Sant'Agata preserves the chapel with precious relics. The temple houses the tombs of numerous Norman, Swabian and Aragonese royalty.

Geophysical surveys were undertaken inside and outside the cathedral (Fig. 2) in order to obtain information about the buried structeres presents in the subsoil of the church.

Fig. 2. The phases of GPR data acquisition

II. GPR DATA ANALYSIS

GPR data were acquired using the Ris Hi-mod radar system with a dual band antenna 200 - 600 MHz. Several areas were acquired (Fig. 3) with a parallel and orthogonal profiles 0.25m spaced. The processing was performed with GPRSlice software [1].

The processing flow-chart consists of the following steps: (i) frequency filtering; (ii) manual gain, to adjust the acquisition gain function and enhance the visibility of deeper anomalies; (iii) customized background removal to attenuate the horizontal banding in the deeper part of the sections (ringing), performed by subtracting in different time ranges a 'local' average noise trace estimated from suitably selected time–distance windows with low signal content (this local subtraction procedurewas necessary to avoid artefacts created by the classic subtraction of a 'global' average trace estimated from the entire section, due to the presence of zones with a very strong signal); (iv) estimation of the average electromagnetic wave velocity by hyperbola fitting; (v) Kirchhoff migration, using a constant average velocity value of 0.07 m/ns. The migrated data were subsequently merged together into three-dimensional volumes and visualized in various ways in order to enhance the spatial correlations of anomalies of interest. A way of obtaining visually useful maps for understanding the plan distribution of reflection amplitudes within specific time intervals is the creation of horizontal time slices. These are maps on which the reflection amplitudes have been projected at a specified time (or depth), with a selected time interval [2]. In a graphic method developed by [2], termed 'overlay analysis', the strongest and weakest reflectors at the depth of each slice are assigned specific colours. This technique allows the linkage of structures buried at different depths. This represents an improvement in imaging because subtle features that are indistinguishable on radargrams can be seen and interpreted in a more easyily. In the present work the time-slice technique has been used to display the amplitude variations within consecutive time windows of width Δt=5 ns. Moreover the highest amplitudes were rendered into an isosurface [2]. Three-dimensional amplitude isosurface rendering displays amplitudes of equal value in the GPR study volume. Shading is usually used to illuminate these surfaces, giving the appearance of real archaeological structures. In this case the threshold calibration is a very delicate task in order to obtain useful results. In order to define the depth of archaeological remains the electromagnetic (EM) wave velocity, using the characteristic hyperbolic shape of a reflection from a point source (diffraction hyperbola), was used.

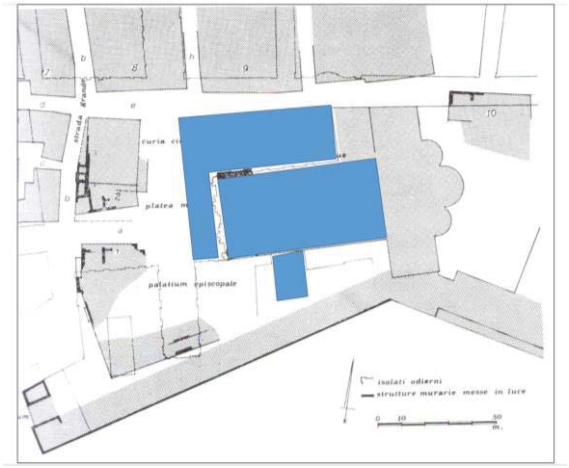

Fig. 3. The GPR surveyed areas

Figs. 4 and 5 shows the depth slice 0.7m and 1.2m related to the 600MHz processed data. In the slices high-amplitude alignment is visible (dashed dark circle). They are related to the unknown extension of the buried roman bath. Other high amplitude anomalies (dotted black box) labelled T are probably related to the presence of tombs.

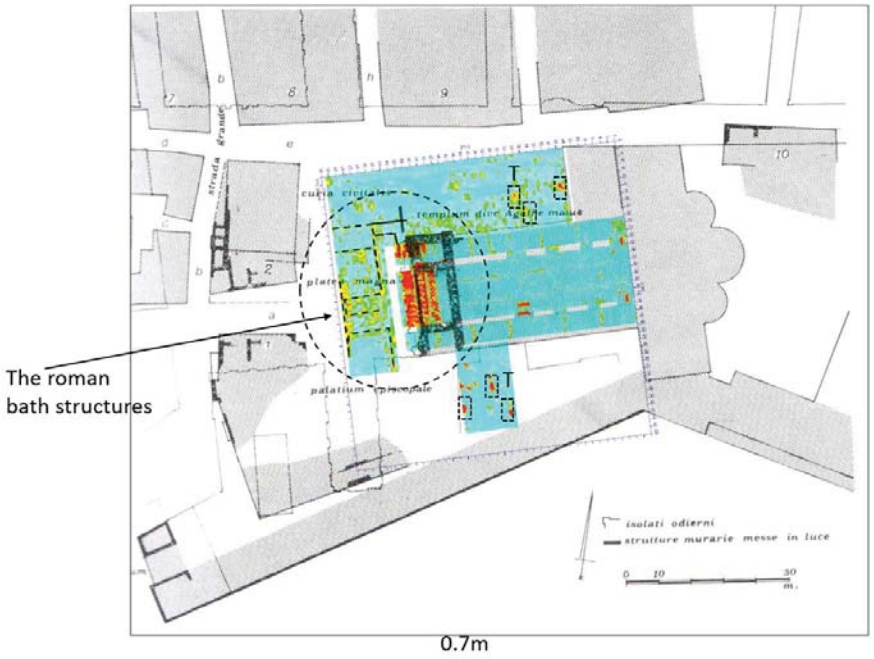

Fig. 4. The GPR depth-slice at 0.7m in depth

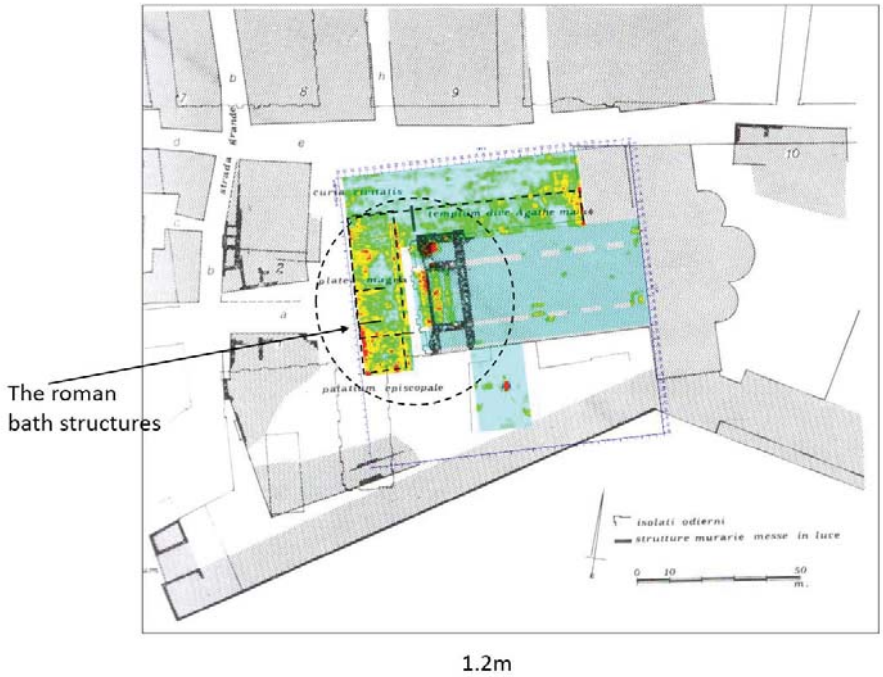

Fig. 5. The GPR depth-slice at 1.2m in depth

amplitude.

Fig. 6 shows the iso – surface of the electromagnetic wave

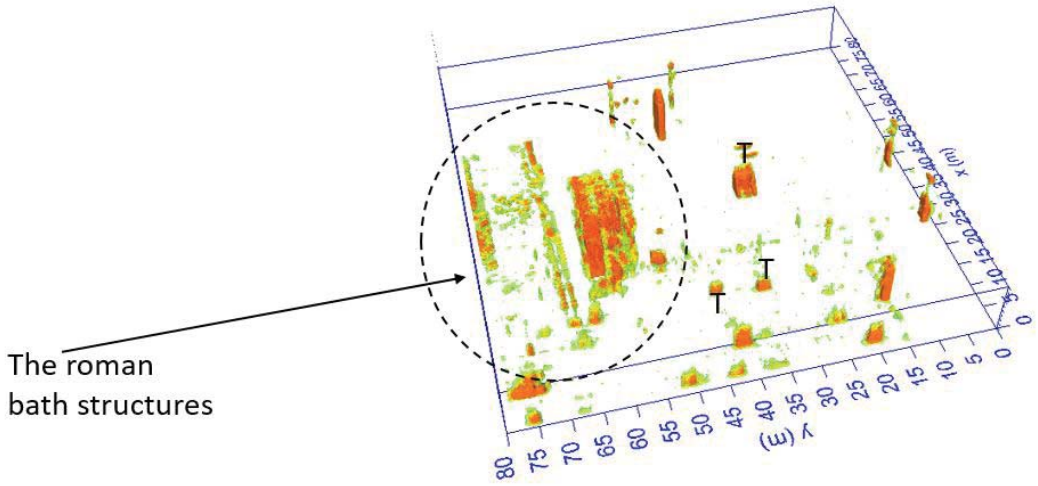

Fig. 6. The GPR 3D iso – amplitude visualization

This visualization allow to better understand the 3D development of the buried structures.

III. CONCLUSIONS

In this paper the results of a GPR survey performed in the Cathedral of Catania were presented. The aims of the survey were the assessment of the shallower underfloor layers in the church and possibly the identification of the tomb and other structures of archaeological interest. The survey was performed both inside and around the Cathedral. The data were processed through gprslice commercial code. In particular, results have shown the presence of unknown structures related to the roman bath and some tombs.

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