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Contribution of Ground Penetrating Radar and Electrical Resistivity Tomography to identify the cavity and fractures under the main Church in Botrugno (Lecce, Italy)

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Abstract

The ''Chiesa Matrice'' is the main Church of Botrugno village, located about 70 km south-east of Lecce (Italy). The church was built between the end of 1500 BC and the beginning of 1600 BC.

In the June 2002 a restoration work has been started to secure the church which suffers from weakened subsoil. Therefore, the structure of the subsoil of the church had to be outlined.

Ground Penetrating Radar (GPR) and 3D Electrical Resistivity Tomography (ERT) geophysical surveys have been integrated to identify the possible presence of voids and fractures in the subsoil.

At accessible spaces around the church only GPR profiles were obtained.

GPR analysis has revealed the high electromagnetic (EM) energy attenuation (almost surely due to the presence of water filling the subsoil and the pavement). Despite the EM energy attenuation the processing and the interpretation of the GPR data point out the presence of voids and fractures.

3D ERT surveys, performed using an area of 10 × 15 m, confirmed the presence of water in the subsoil and allowed to locate a cavity at about 2 m in depth.

Even if the presence of several scaffolds within the building does not allowed to collect the GPR data in order to get a 3D visualization, the comparison between the map of the anomalies obtained with GPR measurements and the 3D ERT, confirmed the effectiveness of the geophysical application presented in this paper and allowed to assess the subsoil conditions of the sacred building.

Keywords: Church; GPR; ERT; Cavities; Subsoil conditions

1. Introduction

Botrugno village is located about 70 km south-east of Lecce (Italy). It is placed 90 m a.s.l. and, geologically, it is constituted, like the greatest part of the Region, of terrain of a karstic nature in which, often, fracture phenomena allow the water to fill in the earth formations.

The ''Chiesa Matrice'' lays on an area in which grey calcarenite crops out.

It was built between the end of 1500 BC and the beginning of 1600 BC, in the main square of the village, over the rest of Saint Rocco's church. Initially, the building was very small (50 m^2), but after the widening and rebuilding works, made in 1715, 1756, 1960 and 1963, the church reached its actual dimension of about 1200 m^2 (Fig. 1). Within the sacred building are actually visible nine altar and several inscriptions.

Restoration process was undertaken in the valuable church and it was a prime goal to estimate the subsoil conditions. Geophysical survey was therefore considered as means of determining the properties of the church subsoil (voids, fractures, etc.).

The interpretation of the results is not always unique and local destructive inspections are sometimes needed to solve

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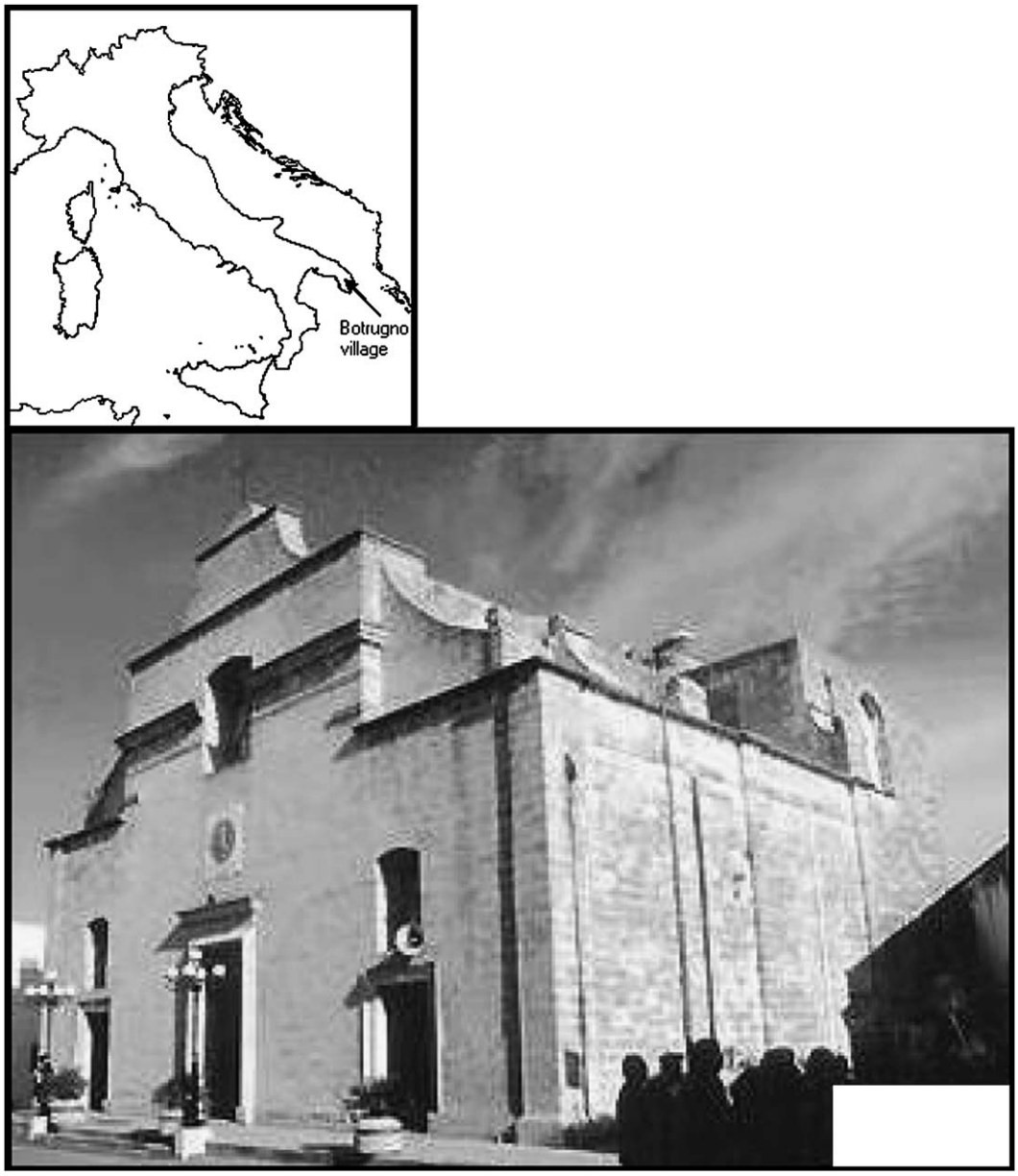

Fig. 1. Botrugno village (Lecce, Italy) location with the photo of the Main Church.

the ambiguities. Unfortunately, these inspections are not always possible, especially for historical buildings, because of restrictions from the authorities for their preservation. Thus, more efforts are necessary to solve these ambiguities with non-invasive methods, such as by combining different geophysical methods.

Geophysical survey has been applied in a variety of studies including: soils mapping, as well as engineering and geotechnical investigations [1,4,5,9,12,14]. However it is not always immediate to compare the results of these studies because of the different field conditions.

Two geophysical techniques were applied to the church. A GPR survey has been performed using the SIR 3000 Radar System device of GSSI attached to an antenna of 400 MHz (bistatic antenna). The data have been processed (filtered, gained and printed) using the REFLEX program [13].

Dipole–dipole ERT survey has been carried out, in an area of 10×15 m, by means of a Syscal-R2 Resistivity-meter of IRIS. The collected data have been drawn as pseudo-sections and then processed using the program RES3DINV [11].

The high attenuation of the EM energy (almost surely due to the presence of water filling the subsoil and the pavement) decreased the investigation depth of the GPR pulses that, locally, reach about 1 m. Furthermore the presence of several obstacles (such as scaffolds and metallic tubes due to restoration works) within the church did not allow to collect the GPR data in order to get a 3D visualization. Despite the presence of the mentioned obstacles, the 3D ERT survey was performed and the integrated data interpretation allowed some interesting considerations, about the presence of voids and fractures, to be done.