

GPR PROSPECTING WITH THE SUPPORT OF HISTORICAL ARCHIVE RESEARCH: THREE CASE STUDIES IN LECCE, ITALY

Giovanni LEUCCI^{1*}, Fabio GRASSO², Raffaele PERSICO¹, Lara DE GIORGI¹

¹ Institute for Archaeological and Monumental Heritage IBAM-CNR,

² External collaborator

Abstract

In this paper, we show the results of three case histories where GPR prospecting has been interpreted also with the aid of a specific archive research on documents of the XVI and XVII century. The case histories are related to three churches of the renaissance and baroque period in Lecce, Lecce, Southern Italy. The aim is to deliver the usefulness of GPR prospecting in these kind of monuments and to show how the likelihood of the interpretation can be increased when historical information is available.

Keywords: *Archaeology; Baroque; GPR; Monuments.*

Introduction

The monitoring of historical monuments is an issue of great interest in the framework of Ground Penetrating Radar (GPR) prospecting [1-8]. Its valence is twofold. In fact, on one side it allows, in many cases, to identify possible fractures, buried voids and other anomalies possibly relevant in relationship with the stability of the structure and/or to be taken into account in view of possible restoration works. On the other hand, it can provide information of historical relevance with regard to the monument at hand and possibly with regard to the changes experienced by the structure through the centuries. Finally, the fact that GPR prospecting is non invasive is particularly appealing in the case of historical monuments, if not (in some cases) mandatory.

In particular, the town of Lecce and the surrounding area, the so called Salento, in Southern Italy, contain many monuments (especially churches, but not only) dating back to the XVI-XVIII century, some of which architecturally important. As it often happened in churches, also in this area during the past centuries many dead people were buried somewhere under the naves. However, subsequent works often erased any external tracks of these tombs. Of course, not all the tombs are historically important, and not all of them are easily attributable even after their excavation. Notwithstanding, in some cases interesting results can be worked out. In particular, we have performed three GPR prospecting in part of three churches, and in all the cases have identified relevant buried structures. In all the cases the main anomalies are likely to be ascribable to funerary structures, but often the buried targets are quite bigger than a single

* Corresponding author: g.leucci@ibam.cnr.it

grave. Such a coincidence makes us statistically think that many interesting secrets might be still hidden under the renaissance and baroque churches of Lecce and Salento, and makes us also deem that a systematic GPR prospecting would provide useful and interesting maps of the underground of the baroque churches. Possibly, such a monitoring would have even some touristic appeal, somehow showing to people the unavailable part of the monuments. We will show the three case histories of the churches of San Giovanni Battista (also named church of the Rosary), the church of Sant'Antonio della Piazza (also named church of San Giuseppe) and the church of San Sebastiano (now deconsecrated). For each case, we will show the most meaningful horizontal slices and will provide an interpretation with the aid of an historical research among the available documents of the past centuries.

The Three Case Histories

In this section a minimal historical presentation of the three probed churches is presented.

The church of San Giovanni Battista was built starting from the year 1691 according to the project of Giuseppe Zimbalo [9], which was the most famous sculptor and architect of the baroque period in this area. The current church was built over a previous church of the XIII century, of which no apparent evidence is preserved (but possibly some foundations of the current building are those of the previous one). The current church, however, was larger than the previous one, and its construction also required the demolition of another pre-existing building, that was named "Island of the Paradise". The new church was ended in 1728, after the death of Giuseppe Zimbalo (occurred in the year 1710 when he was ninety years old). The area interested by the GPR prospection presents three altars. The central one, dedicated to the Rosary, was built under the patronage of the noble family Lubelli (as worked out from some available documents of that period). The left hand altar, dedicated to the Nativity of our Lord, reports the stemma of the noble family Tarallo. The right hand altar is dedicated to the Nativity of the Virgin.

The first edifice of the church of Sant'Antonio della Piazza was built under the direction of Gian Giacomo dell'Acaya [10], a famous architect of the Renaissance in this area (he cured the reconstruction of the town of Acaya, near Lecce). At that time (about 1568) the church comprised a monastery too, demolished in the XX century during the fascist period. The church was meaningfully enlarged already a few years after its first construction, and in particular the main portal reports the date 1585. A second important enlargement was performed in the XVIII century, and in particular, the main nave of the previous church became the transept of the new church. The sculptures and the decoration of the current facade are of the XVIII century, and were done by the local architect and sculptor Giuseppe Serio.

The church of San Sebastiano (now deconsecrated) is located near the Cathedral in the heart of the historical center of the town of Lecce. The church was probably built upon the foundations of a pre-existing crypt, probably of early Christian Age, dedicated to the Saints Leonardo, Sebastiano and Rocco. Someone says that in this church were buried the remains of the patron of Lecce, St Oronzo, first bishop of the town, but no historical proof of this has ever be found. The church was built in 1520 in honor of Saint Sebastian, patron of the victims of the plague [9, 11-13].

Results and Discussions

In this section the achieved results, are shown. In all cases, the data have been achieved by means of a Ris Hi-Mod GPR, manufactured by IDS, equipped with a double antenna with nominal central frequencies 200 and 600 MHz, respectively. The GPR data have been gathered with a transect of 40 cm between any two adjacent measurement line, and the data have been processed by making use of the GPRSLICE code [14]. Particularly, the processing has consisted in zero timing, background removal, gain variable vs. the depth and Kirchhoff migration [15]. The dielectric constant has been retrieved from the diffraction hyperbolas [16]. In particular, here we focus on the results obtained with the antenna at 600 MHz. In the following, the three case histories are separately presented.

Results in the church of San Giovanni

Figure 1 shows a photography of both the facade and the inner of the church of San Giovanni Battista, whereas figure 2 presents the map of the church with the track of the GPR scans is represented. The investigated part is substantially a rectangle sized $13 \times 6.0 \text{ m}^2$. Some GPR profiles are shorter because of the steps of the central altar of the Rosary, as it is clear from the zoom.



Fig. 1. Facade (left hand panel) and internal view of the altar where the GPR prospecting was performed (right hand panel)

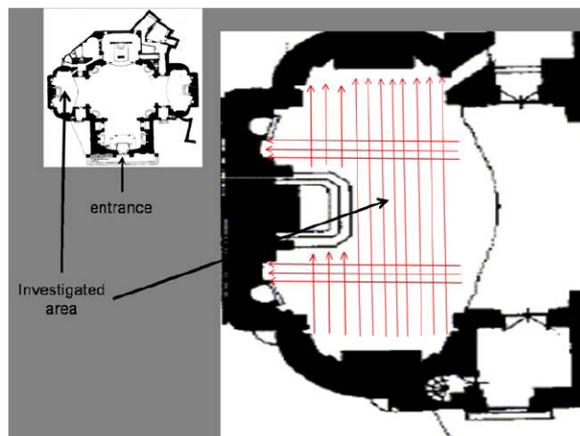


Fig. 2. Map of the Church of San Giovanni Battista with the track of the gathered GPR profiles (red lines)

In figure 3, three horizontal slices at the respective estimated depths of 0.6-0.8m, 0.8-1.0m and 2.4-2.6m are represented. They show the most interesting results among those gathered in this case history.

In particular, a large anomaly appears on the higher part of the 0.6-0.8m slice. We have labeled it as two targets C and D, but actually they might also be just one single anomaly. The shape, the size and the thickness of this anomaly make us think of a corridor, about 1 meter large and 6-7 meters long, possibly bent toward the left hand side at the end. It might be the niche of the family Lubelli, that as said financed the construction of the central altar of the Rosary.



Fig. 3. From left to right: Slices at progressively deeper levels (after the indications) in the church of San Giovanni Battista

The anomaly A and B resemble instead two single graves. One possibility is that these anomalies refer again the tombs of members of the Lubelli family, in which case, the big anomaly C-D might refer to something else. Another hypothesis is that one between the two anomalies A and B (most probably the anomaly A) refers to the tomb of Giuseppe Zimbalo that has been lost. This hypothesis is supported by the fact that Giuseppe Zimbalo, in his last testament, expressed the desire to be buried in the church of San Giovanni Battista and precisely near the altar of the Nativity of our Lord, which corresponds to the position of the anomaly A. He also wrote that, in case his death occurred before finishing the construction of the church (which actually happened, as said), his desire was in any case to be transported in the church of San Giovanni Battista after the end of its construction. To sum up, some uncertainty remains about the single anomalies, but it is quite probable that, comprehensively, the four anomalies were at least partially exploited for the sepulture of some member of the Lubelli family and, possibly, for the last sepulture of Giuseppe Zimbalo.

Results in the church of Sant'Antonio della Piazza

Let us now pass to the Church of Sant'Antonio della Piazza. The monument is shown in figure 4, whereas the map of the church with evidenced the GPR profiles is shown in figure 5.

In figure 5, it is also put into evidence, in dashed line, the plant of a hypogeum crypt that was discovered casually a few years ago, while performing some reinforcing works. It consists of a narrow corridor about 1 meter large and 7 meters long, with three little rooms on the left hand side. The depth of the top of the ceiling (that is cylindrically vaulted) is at the depth of 1.1 meters from the floor of the church, and it is about 4 meters high with respect to the bottom of the crypt.

Actually, there is also a little hole on the lower part of left hand boundary of the crypt, that makes us aware that there is at least another room on the left hand side of the crypt. However, the accessible part (accessible only under permission and through a ladder put in a trapdoor) is just that depicted in figure 5 in dashed line. This crypt has been exploited for sepultures, as it is evident from the many human bones and from the tracks of wooden coffins present inside. The GPR prospecting, however, has highlighted some more aspects. The first one is that the crypt is quite larger than its visible part, and presumably it is at least as large as the entire altar of San Giuseppe (about 8x4m). Maybe, just for its funerary use it was progressively divided into parts progressively walled.



Fig. 4. Left hand panel: the original facade (of XVI century) of the church of Sant'Antonio della Piazza, that today is a lateral entrance; Right hand panel: the altar of Sant'Antonio, inside the church.

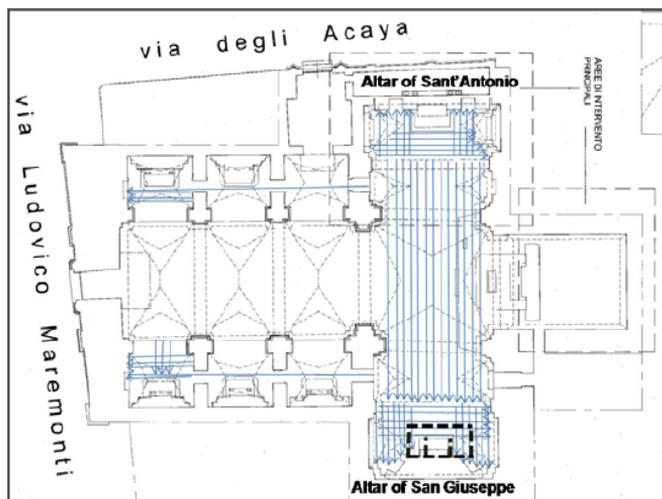


Fig. 5. Map of the Church of Sant'Antonio della Piazza with the tracks of the GPR profiles (blue lines)

However, the GPR prospecting allowed to achieve an even more interesting result on the altar of Sant’Antonio, in front of the altar of San Giuseppe. In fact, similar features were gathered on this altar, which makes us reasonably convinced that under the altar of Sant’Antonio there is a second (upto now completely unknown) hypogeum, also in this case as large as the altar itself (the two altars are not symmetric, but the order of their size is the same). To show this, in figures 6 and 7 one of the GPR profiles gathered on the altar of San Giuseppe and one gathered on the altar of Sant’Antonio are shown, respectively. The data are not processed, in order to show the fact that the evidences are intrinsically quite clear. For each sub-area, the other profiles are quite similar to the chosen “representatives”. It is quite evident that there are anomalies under the lateral altars.

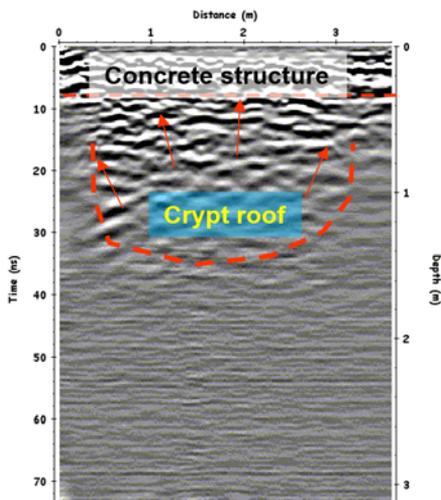


Fig. 6. One of the processed GPR profiles gathered on the altar of San Giuseppe

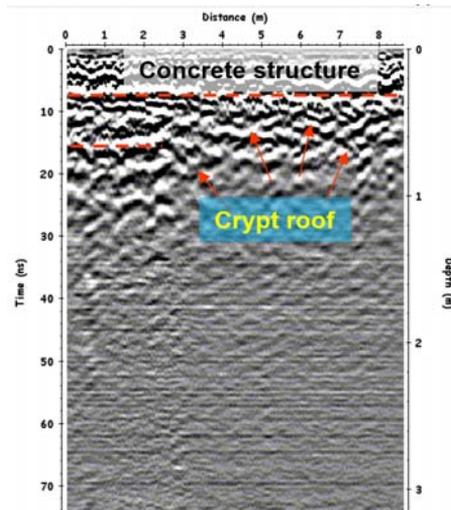


Fig. 7. One of the processed GPR profiles gathered on the altar of Sant’Antonio

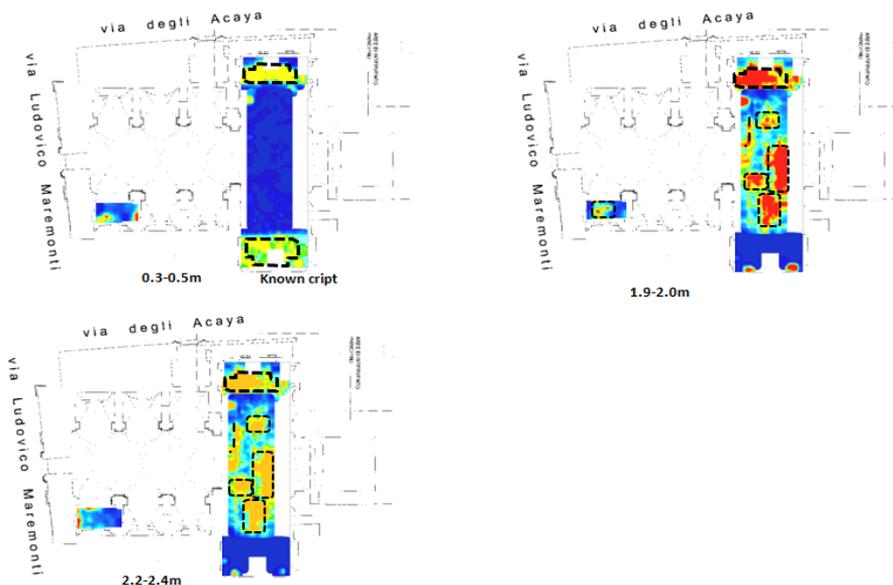


Fig. 8. Slices relative to the most meaningful results achieved in the church of Sant’Antonio della Piazza.

In figure 8 some horizontal slices are shown. In figure 8, the data have been processed according to the procedure described above for the case history of San Giovanni Battista. We have chosen the most interesting depth for each prospected sub-area, according to the labels provided in the figure.

Beyond confirming the already exposed considerations, the processing makes us identify some anomalies, put into evidence in dashed lines. They might be related to hypogeum rooms and/or tombs. Finally, also another anomaly has been identified under the first left hand nave entering from Via Ludovico Maremonti. Its shape, size and depth make us think that it might be a single tomb. On the basis of the available historical documents, we propose the following interpretation: The hypogeum under the altar of San Giuseppe probably served for the sepulture of some members of a “Confraternity of the Carpenters” and dates back to the original period of the church, namely XVI century. Indeed, it might be even pre-existent to the church (we can’t know, but we can’t exclude), but is it definitely improbable that it is posterior. The reason of this supposition is that, at the origin, the current altar of san Giuseppe there was the main altar of the church that (with reference to the figure 5) was essentially extended from the altar of Sant’Antonio to the altar of San Giuseppe.

The transept was the main nave, and the entrance was from the original portal in Via degli Acaya, on the left hand side of the altar of Sant’Antonio. Now, it often happened (even if it was not any prescription) that under the main altar there were sepultures. And it is known that the main altar was patronaged by the quoted Confraternity of the Carpenters, that at that time were numerous in the surrounding of the church. Instead, the altar of Sant’Antonio was near the entrance of the church, and it was definitely more rare to excavate a crypt near the entrance. So, it is more probable that, after the enlargement of the church in XVIII century, with the aperture of the current main entrance in via Maremonti, the hypogeum under the altar of Sant’Antonio was excavated or at least its use for sepultures started. With regard to the single alleged grave visible on the left hand side of the images in figure 8, if it is a tomb, it is probably pre-existent to that part of the church (XVIII century). In fact, even within the natural charge of uncertainty that affects the results all the times, the image clearly indicates that the anomaly is tilted with respect to the main nave, and it is very improbable that a sepulture was not collinear with the church. Incidentally, in the near Via degli Acaya, some messapic tombs (VI-IV century B.C.) have been found some years ago, at shallow depth. This is therefore a possibility, but of course we cannot guarantee.

Results in the church of San Sebastiano

Let us now pass the third case history. In figure 9 two images of the ex-church of San Sebastiano are provided.

The most important results are visible in the horizontal slice proposed in figure 10. The data have been processed in the same way as the other sets described above.

The three main visible anomalies have been labeled with the letters B, C and D. The anomalies are about sized $3.5 \times 2.5 \text{m}^2$, and their depth ranges about from 50cm to 5.4m.



Fig. 9. Facade of the ex-church of San Sebastiano (left hand panel) and an internal view (right hand panel).



Fig. 10. Depth slices in the ex-church of San Sebastiano

The anomaly B is visible at depth 2.0-2.1m. With the regard to the anomalies B, C and D, a probable hypothesis is that they can be referred to a crypt. The anomaly A is instead related to a known excavation performed in the 1970s.

Conclusions

In this paper we have shown some results relative to three case histories regarding monuments of the renaissance and baroque periods in Lecce, southern Italy. This work is the result of a collaboration between authors with different competencies, in particular historical and geophysical. Indeed, the interaction happened also before doing the prospecting, influencing the choice of the areas to be prospected. Hopefully, we have shown that the combination of a proper geophysical prospecting, a proper data processing and the support of

specific historical investigations performed on the investigated monument can produce more reliable results. We are aware that an excavation would be needed in order to fully validate any conclusions, but they are not in order at the moment.

Even so, the awareness of the underlying apparent situation is useful can be an important issue. In particular, beyond a cultural point of view, it might be needed to do works one day, and to be aware of possible voids is important when mounting scaffoldings. In particular, the crypt under the altar of San Giuseppe in the church of Sant'Antonio della Piazza was discovered just while doing needed structural works, and fortunately no accident occurred in that occasion.

References

- [1] G. Leucci, R. Persico, F. Soldovieri, *Detection of Fracture From GPR data: the case history of the Cathedral of Otranto*, **Journal of Geophysics and Engineering**, 4(4), 2007, pp. 452-461.
- [2] P.L. Cosentino, P. Capizzi, R. Martorana, P. Messina, S. Schiavone, *From geophysics to microgeophysics for engineering and cultural heritage*, **International Journal of Geophysics**, 2011, paper no. 428412, <http://dx.doi.org/10.1155/2011/428412>,
- [3] N. Masini, R. Persico, E. Rizzo, A. Calia, M.T. Giannotta, G. Quarta, A. Pagliuca, *Integrated Techniques for Analysis and Monitoring of Historical Monuments: the case of S.Giovanni al Sepolcro in Brindisi (Southern Italy)*, **Near Surface Geophysics** 8(5), 2010, pp. 423-432.
- [4] P.M. Barone, S.E. Lauro, E. Mattei, E. Pettinelli, *Non-destructive technique to investigate an archaeological structure: a GPR survey in the Domus Aurea (Rome, Italy)*, **Proceedings of the XIII-th International Conference on Ground Penetrating Radar**, ISBN 978-1-4244-4605-6, Lecce, 21-25 June 2010, IEEE.
- [5] M. Pieraccini, L. Noferini, D. Mecatti, C. Atzeni, R. Persico, F. Soldovieri, *Advanced Processing Techniques for Step-frequency Continuous-Wave Penetrating Radar: the Case Study of "Palazzo Vecchio" Walls (Firenze, Italy)*, **Research on Nondestructive Evaluation**, 17(2), 2006, pp. 71-83.
- [6] E. Utsi, *The Shrine of Edward the Confessor: a Study in Multi-Frequency GPR Investigation*, **Proceedings of the XIII-th International Conference on Ground Penetrating Radar**, ISBN 978-1-4244-4605-6, Lecce, 21-25, June 2010, IEEE.
- [7] G. Leucci, *Ground-penetrating radar survey to map the location of buried structures under two churches*, **Archaeological Prospection**, 9(4), 2002, pp. 217-228.
- [8] L.M. Angheluta, D.V. Ene, *An interdisciplinary field campaign for modern investigation and monitoring in preservation and restorationi*, **International Journal of Conservation Science**, 6(S1), 2015, pp. 455-464.
- [9] A. Laporta, **Cronache di Lecce**, Edizioni Del Grifo, Lecce, 1991.
- [10] G.C. Infantino, **Lecce Sacra**, 1634, (A cura di M. De Marco), Ristampa Anastatica, Gallipoli 1988.
- [11] L. De Simone, **Lecce e i suoi monumenti**, vol. I, La città, Nuova edizione postillata da Nicola Vacca, Centro Studi Salentini, Lecce, 1964.
- [12] J. A. Ferrari, **L'Apologia Paradossica della città di Lecce**, Lecce, 1706, available online at http://www.culturaserivizi.it/vrd/files/apologia_paradossica_citt%C3%A0_lecce_indice.pdf, [accessed in November 2015].

- [13] F. Grasso, *Il nome del padre del barocco di Terra d'Otranto*, **L'Ora del Salento**, Nuova Serie, Anno XX, 30, Lecce, 2010, pp. 8-9.
- [14] D. Goodman, **GPR Slice Version 7.0 Manual**, 2013, available online at <http://www.gpr-survey.com>, [accessed in November 2015].
- [15] R. Persico, **Introduction to Ground Penetrating Radar: Inverse Scattering and data processing**. Wiley, 2014, ISBN 9781118305003.
- [16] R. Persico G. Leucci, L. Matera, L. de Giorgi, F. Soldovieri, A. Cataldo, G. Cannazza, E. De Benedetto, *Effect of the height of the observation line on the diffraction curve in GPR prospecting*, **Near Surface Geophysics**, **13**(3), 2015, DOI: 10.3997/1873-0604.2014042.

Received: April, 24, 2015

Accepted: November, 10, 2015