Archaeologia Polona, vol. 53: 2015, 248-251

Georadar study of early structures under the Hagia Sofia, Istanbul, Turkey

Luis Barba[a], Jorge Blancas[a], Marco Cappa[c], Murat Cura[b], Gino Crisci[b], Daniela De Angelis[c], Domenico Miriello[b], Alessandra Pecci[b] and Hasan B. Yavuz[d]

KEY-WORDS: urban archaeology, architecture, laser scanner, georadar, Hagia Sofia, Istanbul

INTRODUCTION

As part of an international project for the examination of the Hagia Sofia monument, carried out by an interdisciplinary team from the University of Calabria and the University of Mexico, varied techniques were applied, including 3D laser scan, thermography, mortar analysis and georadar (Cura *et al.* 2014).

The monument has a very long building history. It seems that the first church, built close to the current location, was completely destroyed by fire in AD 404 (Mainstone 2009). The second church, built in AD 415, was also destroyed by a fire in AD 532, during the Nika revolt. A new building started to be constructed immediately by the Emperor Justinian I and was opened in AD 537. Therefore, it is possible that the remains of the second church were preserved under the present floor. For this reason, it was decided to carry out a georadar survey of the central area of the building to see whether the underground structures could be responsible for the deformation of the building. Our measurements and observations confirmed the deformation of the entire structure (van Nice 1965; Mainstone 2009). The present paper discusses the results of the georadar survey of the southern part of the nave of the Hagia Sofia, the northern part being out of bounds owing to the scaffolding raised there for the purpose of restoration works.

METHODOLOGY

The georadar study was carried out employing the GSSI SIR 3000 instrument with 400 MHz antenna and survey wheel on lines every 0.5 m from south to north, penetrating to a depth of over 4 m.

[a] Laboratorio de Prospección Arqueológica. Instituto de Investigaciones Antropológicas. Universidad Nacional Autónoma de México. México
[b] DiBEST Dipartimento di Biologia, Ecologia e Scienze della Terra. Università della Calabria. Italy.
[c] Restructura – Surveys for Cultural Heritage, Cosenza, Italy
[d] SISTEM A.S., Leica Geosystems AG., Turkey Distributor

Earlier experience with the same methodology in other places, obtained by the Archaeological Prospection Laboratory, revealed the suitability of georadar measurements for providing information on the substructure below the prospected floors.

RESULTS

The marble surface of the floor in the nave of the Hagia Sophia is quite homogeneous. Nevertheless, there are some areas with different characteristics. Some changes were caused by archaeological excavations from the 1950s in the western part of the nave (van Nice 1965).

Other broad reflections probably related to the presence of earlier architectural structures below the floor were also traced (Fig. 1). These reflections show a high contrast in properties between the aligned stones and the earthen matrix. Earlier archaeological excavations near the main entrance of the building discovered two thick parallel walls running east–west, equidistant from the central axis. The 1.5 m depth slice (Fig. 1) reveals the said walls. The wall closing the structure by the eastern side is clearly visible at a depth between 1.2 m and 1.6 m, while the wall on the southern side reaches almost 2 m in depth.

Taking into consideration these data a hypothetical reconstruction of the plan of an ancient building underlying the present floor can be proposed. Duplicating the half of the structure identified in the georadar study with a symmetrical reflection of the surviving remains, it is possible to suggest the presence of a whole building.

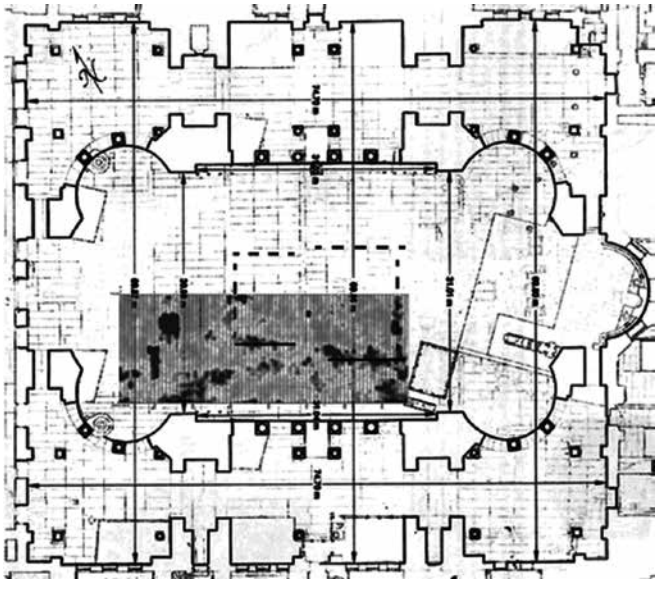

Fig. 1. Plan of the ground floor of the Hagia Sofia (modified after van Nice 1965), showing 1.5 m depth slice and the most feasible interpretation of the shape of a substructure, obtained by mirroring the wall traces detected in the southern part of the area

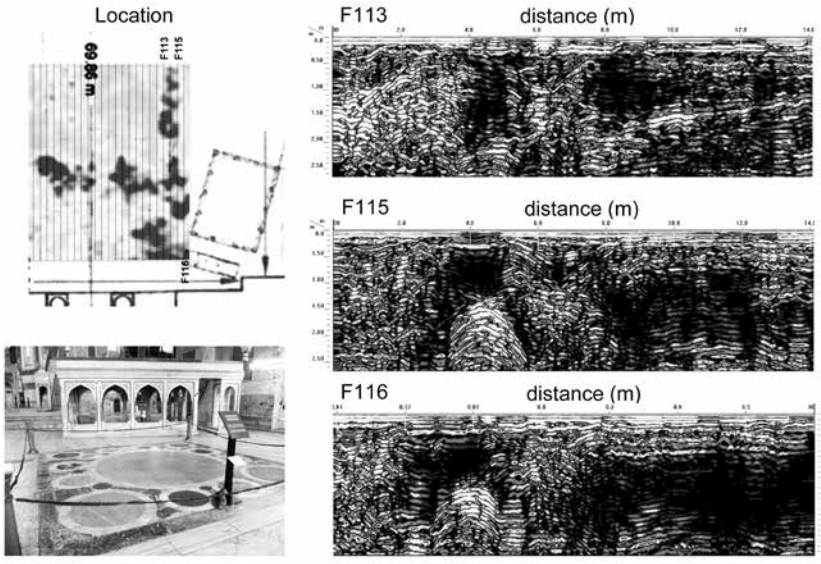

Fig. 2. Radargrams of three lines that show important reflections below the marble mosaic

In the individual radargrams F115 and F116, at 2 m depth and 4.5 m distance, there is a clear hyperbolic reflection (Fig. 2). Taking into consideration six parallel radargrams, they show an important reflection (at least 3 m long and 2 m wide) that seems to connect a point below the surface close to the center of the mosaic to some point under the muezzin's gallery to the east. In radargram F116, two walls are visible bordering the hyperbolic reflection in the center.

FINAL REMARKS

The interpreted building looks rather small, 22 m E–W and 16 m N–S, and should be located at less than 2 m depth. Its true dimensions and the symmetry of the building will be verified as soon as the scaffolding is removed, which will make it possible to carry out the georadar survey of the northern part.

The interpretation of the georadar results of the southern part of the floor in the nave of the Hagia Sofia indicates many architectural remains buried at apparently different levels, suggesting the presence of earlier structures. Moreover, the identification of a structure under the marble mosaic suggests that an unexpected relationship exists between them and seems to indicate that the mosaic was placed there to mark the presence of an important feature below.

Nevertheless, the topographic map from the laser scanning of the building reveals no deformations or topographic changes in the nave floor surface (Fig. 3). It means that although there are at least two levels of important architectural remains under the current floor of the Hagia Sofia, the central part of the floor is stable, with almost no deformations. Therefore, the results have not confirmed the idea that the visible deformations of the Hagia Sophia structure are caused

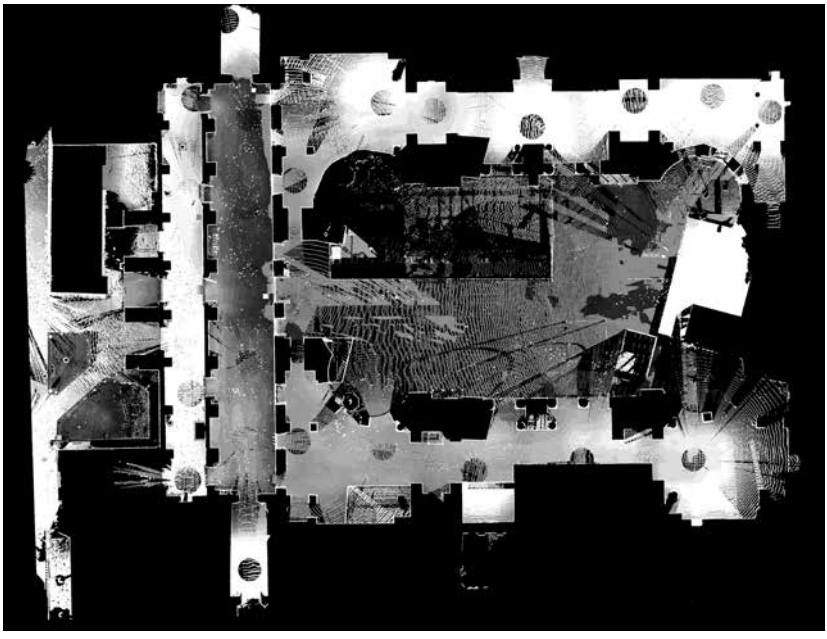

Fig. 3. Topographic map of the ground level of Hagia Sofia obtained by Leica Geosystems' Scan Station 2. There is a uniform flat grey area in the nave. Whitish areas are the higher levels in the east corner of the gallery, the dark grey area in the west corner is the deepest. The interval between two extreme points is 0.5 m

by earlier architectural remains below the central part of the building. These deformations must be caused by other factors and it is clear that the earlier structures were carefully covered, using suitable materials and proper compacting.

ACKNOWLEDGMENTS

We are grateful to the Direction of the Ayasofya Müzesi for their permission and collaboration, and to the Ministry of Culture and Tourism of Ankara for permission to carry out the research.

REFERENCES

Cura, M., Pecci, A., Miriello, D., Barba, L., Cappa, M., De Angelis, D., Blancas, J. and Crisci, G.M. 2014. Multi-analythical approach for the diagnostic at Hagia Sophia: a 3D multimedia database proposal. *Annual of Hagia Sophia Museum* 14: 379-403.

Mainstone, R. J. 2009. *Santa Sofia.* Mondadori Electra, Milan.

Van Nice, R.L. 1965. *St Sofia in Istanbul: an architectural survey.* Dumbarton Oaks Center for Byzantines Studies Trustees for Harvard University, Washington D.C.