COST Action TU1208

Civil Engineering Applications of Ground Penetrating Radar

An overview on the studies carried out by Action Members in the field of Archaeology and Cultural-heritage

Final Meeting,
National Institute of Telecommunications,
25-27 September, 2017,
Warsaw, Poland

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Archaeological Prospection

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Archaeology

Two significant projects carried out by scientists participating to COST Action TU1208 need to be mentioned, namely the Carnuntum (*Neubauer et al., 2014*, *Valdelomar et al., 2015*) and the "Stonehenge Hidden Landscape Project" (*De Smedt and Trinks, 2014*).

Neubauer, W., Gug, C., Scholz, M., Verhoeven, G., Trinks, I., Locker, K., Doneus, M., Saey, T. O., and Van Meirvenne, M. 2014. The discovery of the school of gladiators at Carnuntum, Austria. Antiquity. 88: 173–190, doi: 10.1017/S0003598X00050298

Valdelomar, J.T., Brandtner, J., Kucera, M., Wallner, M., Sandici, V., Neubauer, W. 2015. 4D investigation of Digital Heritage: An interactive application for the auxiliary fortress of Carnuntum. Proc. 2015 Digital Heritage International Congress, Digital Heritage 2015: art. no. 7419457, 81-84.

De Smedt, P. and Trinks, I. 2014. STSM 4: Reconstructing Prehistoric Environments at Stonehenge with Multiple Electromagnetic Survey Methods. Short Term Scientific Missions and Training Schools – Year 1, Aracne, ISBN 978-88- 548-7225-7: 64-76.

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Archaeology

The site of the Roman town of Carnuntum is located about 30 km south-east of Vienna, in Austria, extends over an area of about 10 square kilometres. The whole area of Carnuntum, comprising a civil town as well as a military camp and settlement, has been mapped in great detail. Magnetometer systems for large-scale prospection earth-resistance measurements, remote-sensing techniques, and different single-channel and multi-channel GPR systems have been used. Extraordinary results have been obtained, including the unique discovery of the school of gladiators. Such structure has been first mapped with a single channel 900 MHz GPR system, and subsequently investigated in great detail using a multichannel 400 MHz array with only 8 cm crossline spacing.

More information is available at:
http://lbi-archpro.org/cs/carnuntum/

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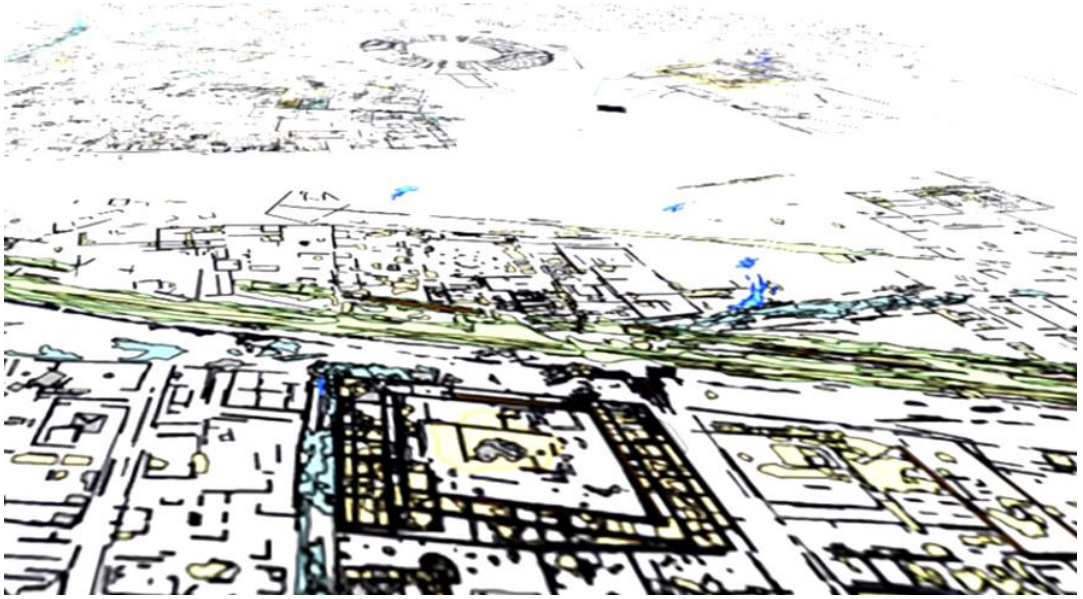
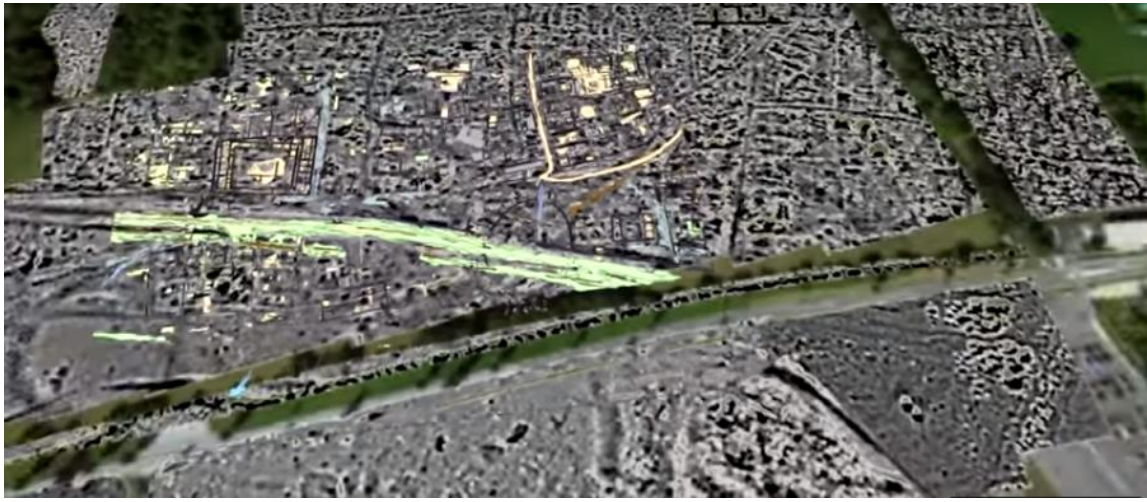
Archaeology
Carnuntum





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Archaeology

Stonehenge (United Kingdom) occupies one of the richest archaeological landscapes in the world, where archaeological and antiquarian research has been intensively carried out over centuries. The aim of the "Stonehenge Hidden Landscape Project" was to address gaps in our knowledge and advance the understanding of the Stonehenge landscape, by conducting a cutting-edge geophysical- and remote-sensing survey at unprecedented scale. Hundreds of new features were discovered and a detailed archaeological digital map of the Stonehenge landscape was produced.

More information is available at:
http://lbi-archpro.org/cs/stonehenge/

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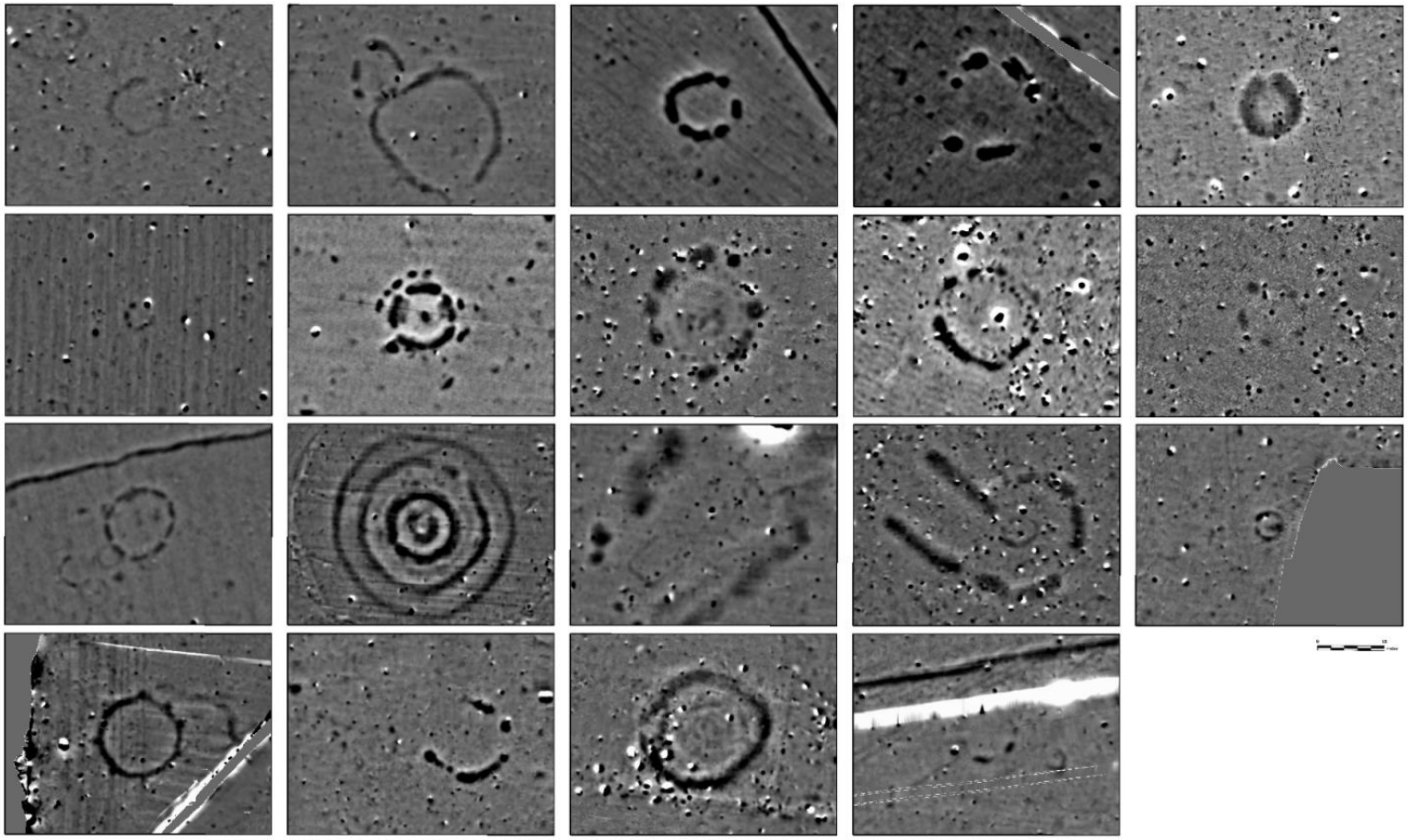
Archaeology

Stonehenge



More information is available at:

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Monuments

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Monuments

GPR evaluation of the Tholos Acharnon Tomb (Athens, Greece), an ancient Mycenaean monument dating back to the XIII century BC (*Santos-Assunçao et al., 2016*). This is a circular and buried structure, made with irregular stones. The curved surfaces of the tomb represented a challenge for data acquisition and interpretation. During data acquisition a laser scan was used, in order to record the position and path of each radargram. The most interesting result is the description of the internal structure of the tomb walls; furthermore, zones where the GPR signal was highly attenuated were identified, probably due to a high salt content.

Santos-Assunçao, S., Dimitriadis, K., Konstantakis, Y., Perez-Gracia, V., Anagnostopoulou, E., and Gonzalez-Drigo, R. 2016. Ground-penetrating radar evaluation of the ancient Mycenaean monument Tholos Acharnon tomb. Near Surface Geophysics 14(2): 197-205, doi: 10.3997/1873-0604.2015030.

Santos-Assunçao, S., Dimitriadis, K., Konstantakis, Y., Perez-Gracia, V., Anagnostopoulou, E., Solla, M., Lorenzo, H., "Non-destructive assessment of the Ancient Tholos Acharnon Tomb Building Geometry", EGU General Assembly 2014, 27 April - 2 May, Vienna, Austria, article ID EGU2014-13961-1.

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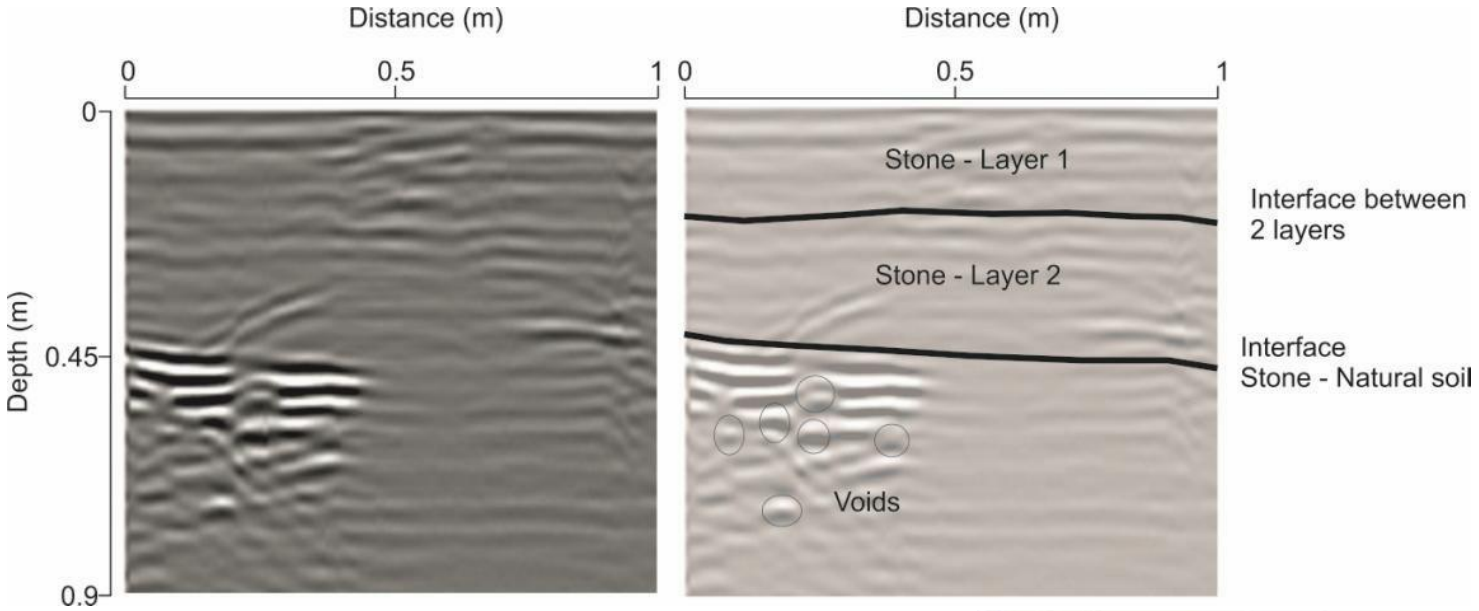
Monuments



Santos-Assunçao, S., Dimitriadis, K., Konstantakis, Y., Perez-Gracia, V., Anagnostopoulou, E., and Gonzalez-Drigo, R. 2016. Ground-penetrating radar evaluation of the ancient Mycenaean monument Tholos Acharnon tomb. Near Surface Geophysics 14(2): 197-205, doi: 10.3997/1873-0604.2015030.

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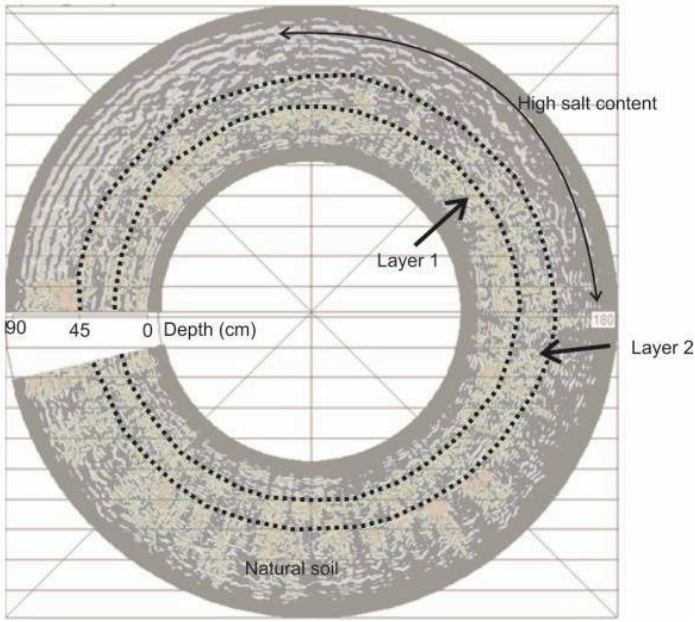

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Monuments

Benedetto et al. (2016) presents the investigation of the St. Leonard's Crypt under the Wawel Cathedral. The activities focused on surveying the floor of the crypt, in order to obtain an image of the tomb of Bishop Maurus, verify whether further cavities were present and collect information about the subsurface of the crypt. It was possible to found out that the tomb of Bishop Maurus is shifted with respect to the inscription placed in the middle of the crypt and supposed to indicate its position. We could also detect the presence of another large cavity and estimate their size. All measurements were performed by using a CX-12 GPR pulsed system of MALA Geoscience.

Benedetto, A., Pajewski, L., Dimitriadis, K., Avlonitou, P., Konstantakis, Y., Musiela, M., Mitka, B., Lambot, S., Zakowska, L. 2016. Ground-penetrating radar investigation of St. Leonard's Crypt under the Wawel Cathedral (Cracow, Poland) – COST Action TU1208", Geophysical Research Abstracts, European Geosciences Union (EGU) General Assembly 2016, 17-22 April, Vienna, Austria, article ID EGU2016-17965.

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Monuments

Kadioglu and Kadioglu (2016) presents the GPR investigation of the Sultan Alp Arslan Tomb of Merv, in Turkestan, built in the XI century. GPR and gradiometer surveys have been carried out. The GPR surveys were performed with a Ramac CU-II system equipped with a 250 MHz shielded antenna, on one meter spaced profiles. Similarly a Geoscan system was used to take magnetic data. The results of all these investigation revealed that there were possible traces for the buried tomb of the Sultan Alparslan in Gavur Kale around Cuma Mosque and around Sultan Sancar Tomb in the study region.

Kadioglu, S., Kadioglu, Y.K. 2016. Investigation of the Sultan Alp Arslan tomb with geophysical methods, in the historical Merv city (Tukerstan). Geophysical Research Abstracts, European Geosciences Union (EGU) General Assembly 2016, 17-22 April, Vienna, Austria, article ID EGU2016-18494.

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Monuments

Kadioglu et al. (2015) presents a GPR prospection on the Midas Monument remained a Phrygia civilization, lived between the 9th and 7th centuries BC. The Midas Monument has taken the shape of a giant rock-cut facade. There are a lot of rock cut chambers seems as a multi-storey apartment in the North of the monument. Both 800 and 250 MHz shielded antenna were used. The results obtained were 2D/3D image with half bird's eye view visualization of depth slices and their transparent 3D sub-volumes and pictured fractures on the Midas Monument and buried cavities representing rock cut tombs between monuments and the rock cut necropolis.

Kadioglu, S., Kadioglu, K.Y., Akyol, A.A. 2015. Picturing monuments and cultural heritages with ground penetrating radar method including its half bird's eye view visualization. Proc. 8th International Workshop on Advanced Ground Penetrating Radar (IWAGPR), 7-10 July, Florence, Italy, pp. 1-4, doi: 10.1109/IWAGPR.2015.7292684.

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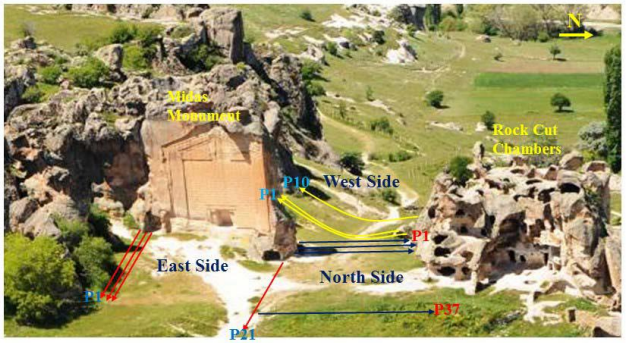
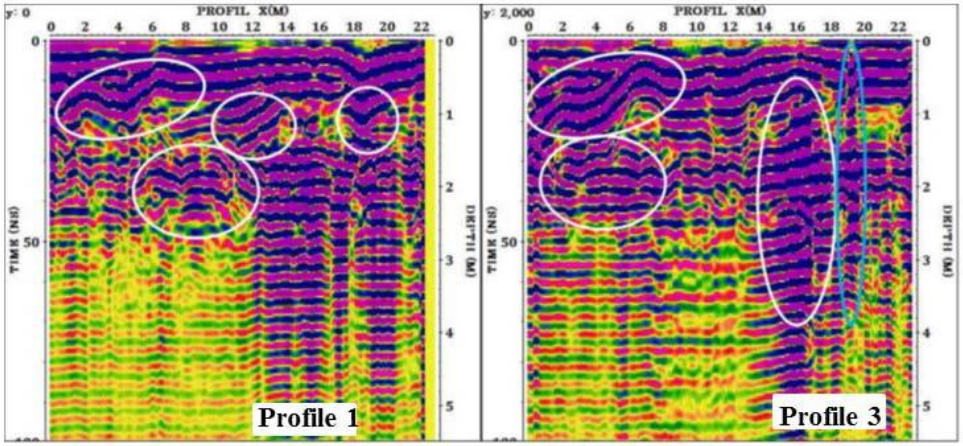
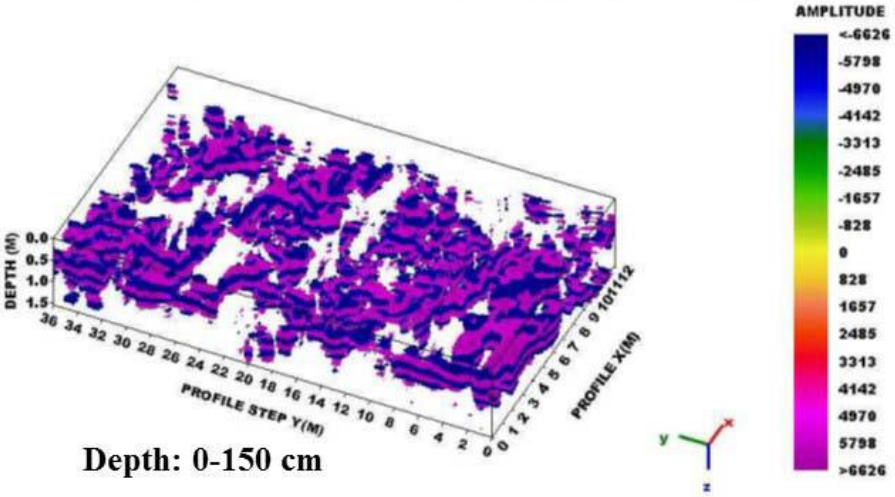
Monuments





Some sample of the buried chambers.



Kadioglu, S., Kadioglu, K.Y., Akyol, A.A. 2015. Picturing monuments and cultural heritages with ground penetrating radar method including its half bird's eye view visualization. Proc. 8th International Workshop on Advanced Ground Penetrating Radar (IWAGPR), 7-10 July, Florence, Italy, pp. 1-4, doi: 10.1109/IWAGPR.2015.7292684.

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Monuments

Puente et al. (2015) presents a NDT evaluation of the Roman Bridge of Lugo (Spain) that has undergone many restorations throughout the last millennium. It currently supports heavy and constant pressures resulting from traffic loading. Both mobile and static light detection and ranging (LiDAR) devices, integrated with digital cameras, were considered to analyze the exterior of the bridge whereas the ground penetrating radar (GPR) equipment was used to characterize its internal stonework. A 3D textured bridge model is given, which is combined with inner details from GPR. Its analysis could certainly benefit masonry arch bridge inspection.

Puente, I., Solla, M., González-Jorge, H., Arias, P. 2015. NDT Documentation and Evaluation of the Roman Bridge of Lugo Using GPR and Mobile and Static LiDAR. Journal of Performance of Constructed Facilities, vol. 29(1), 2015, doi: 10.1061/(ASCE)CF.1943-5509.0000531.

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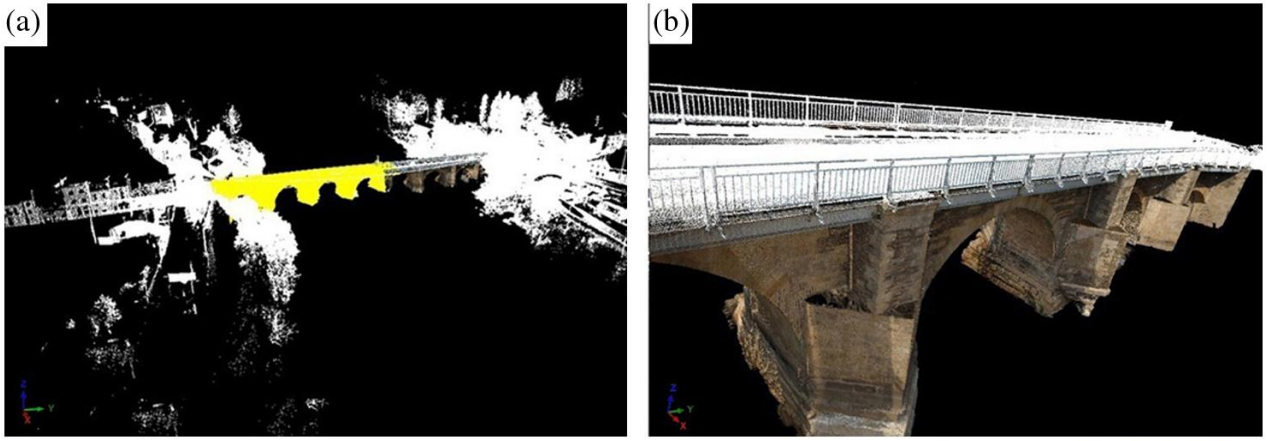
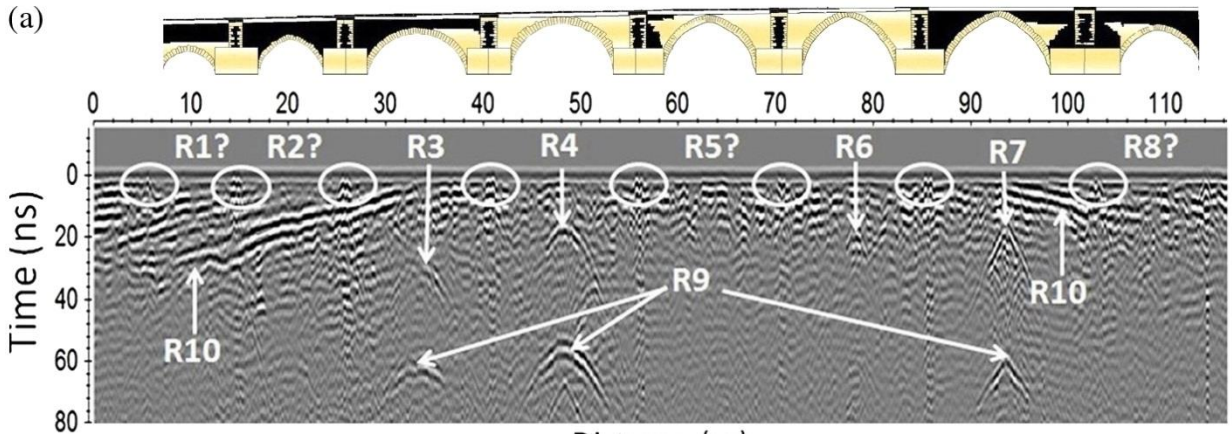
Monuments





R1-R8: arches
R9: water level
R10: ancient profile

Puente, I., Solla, M., González-Jorge, H., Arias, P. 2015. NDT Documentation and Evaluation of the Roman Bridge of Lugo Using GPR and Mobile and Static LiDAR. Journal of Performance of Constructed Facilities, vol. 29(1), 2015, doi: 10.1061/(ASCE)CF.1943-5509.0000531.

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Historical Buildings

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Historical Buildings

Pérez-Gracia et al. (2017) presents three different case studies, all of them about old buildings that need to be restored or modified. The radar study objective was, in all cases, the detection of hidden structural elements. The first case presents the study of some terraces in buildings in order to determine the structural elements and also to determine approximately the materials, previous to an important modification. The second case is based in the study of the ground underneath the building. Several structures that could affect to the further restoration were detected. The last case presents the study of floors in the different levels of a building, showing the changes in the structural elements supporting the floors.

Pérez-Gracia, V., Caselles, O., Clapés, J., Santos-Assunçao, S. 2017. GPR building inspection: Examples of building structures assessed with Ground Penetrating Radar. Proc. 9th International Workshop on Advanced Ground Penetrating Radar (IWAGPR), 28-30 June, Edinburgh, UK, pp. 1-4, doi: 10.1109/IWAGPR.2017.7996071.

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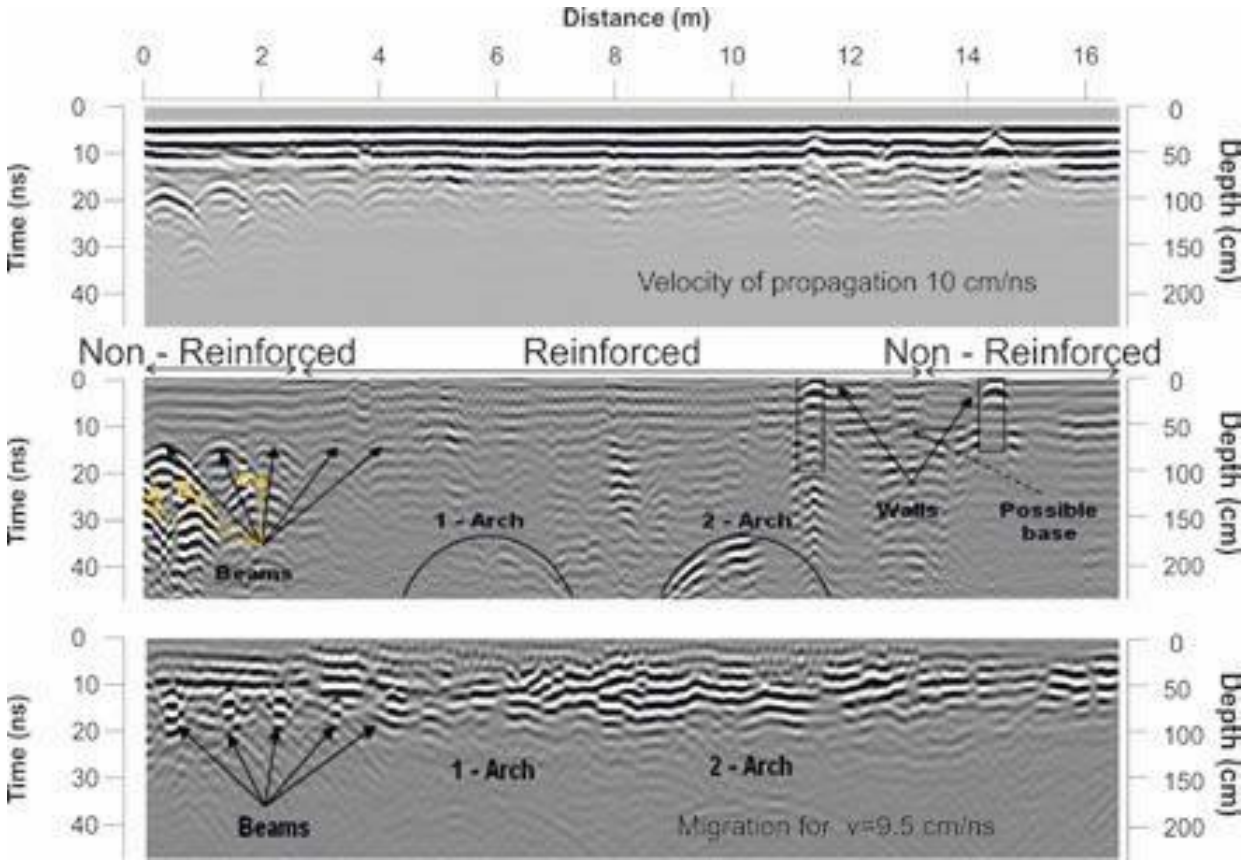
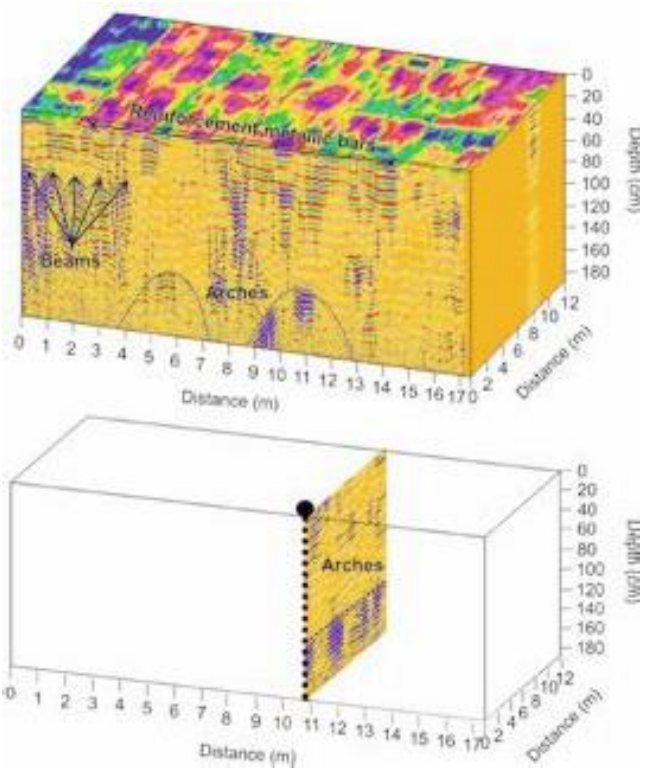
Historical Buildings





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Historical Buildings

Another interesting TU1208 case study was carried out in the Saint Mary Cathedral of Mallorca (Spain), a catalan gothic-style building dating back to the XIV Century (*Pérez-Gracia et al., 2013*, *Santos-Assuncao et al., 2014*). The most important results are related to the investigation of a series of different columns by using GPR combined with seismic tomography, as the application of GPR to vertical structural elements is rather uncommon. Images of the internal structure of the columns were obtained and cracks not visible from outside were identified.

Pérez-Gracia, V., Caselles, J. O., Clapés, J., Martinez, G., and Osorio, R. 2013. Non-destructive analysis in cultural heritage buildings: Evaluating the Mallorca cathedral supporting structures. Non Destructive Testing and Evaluation International 59:40–47, doi:10.1016/j.ndteint. 2013.04.014

Santos-Asssunçao, S., Pérez-Gracia, V., González, R., Caselles, O., Clapés, J., Salinas, V. 2014. Geophysical exploration of columns in historical heritage buildings. Proc. 15th International Conference on Ground Penetrating Radar (GPR 2014), Brussels, Belgium, 30 June – 4 July 2014: 97-102, doi: 10.1109/ICGPR.2014.6970393

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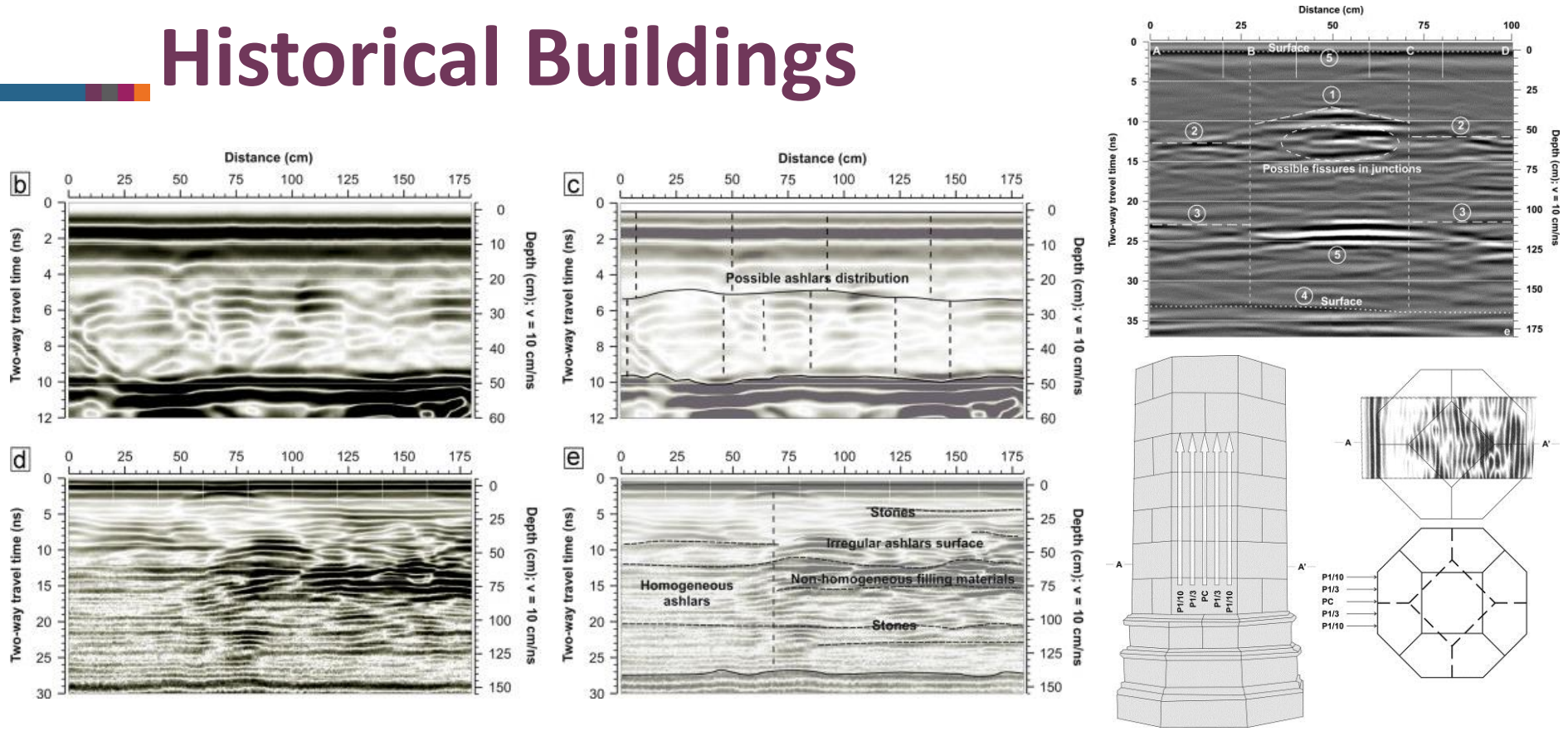
Historical Buildings



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Historical Buildings

Pérez-Gracia et al. (2015) presents the GPR assessment of the Santa María del Mar (Barcelona). It is a magnificent gothic church built between 1329 and 1383 over the remains of a more ancient church. Radar images demonstrate that the inner structure was designed in order to diminish the load on the arches and walls. Hollow elements were used to support partly the roof in some areas. A large number of graves were located under the church floor, but also some of the radar images suggest the existence of large underground walls. The GPR study of the columns and walls was completed with a seismic survey that demonstrates the existence of zones of non-consolidated materials and defined the joints of the ashlars.

Pérez-Gracia, V., Caselles, J. O., Clapés, J. 2015. Ground penetrating radar assessment of historical buildings: the study of the roofs, columns and ground of the Santa María del Mar, in Barcelona. Microwave symposium, 2015, IEEE 15th Mediterranean, Lecce, pp. 1-4, doi:10.1019/MMS.2015.7375496.

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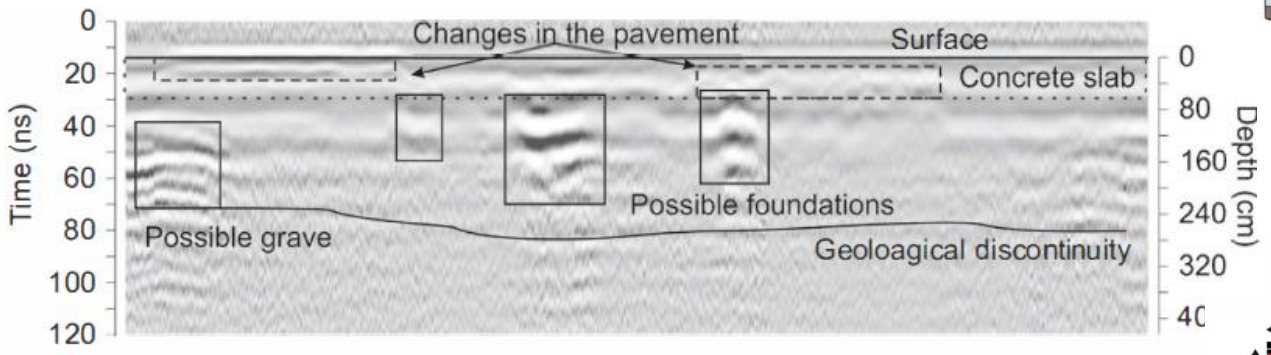
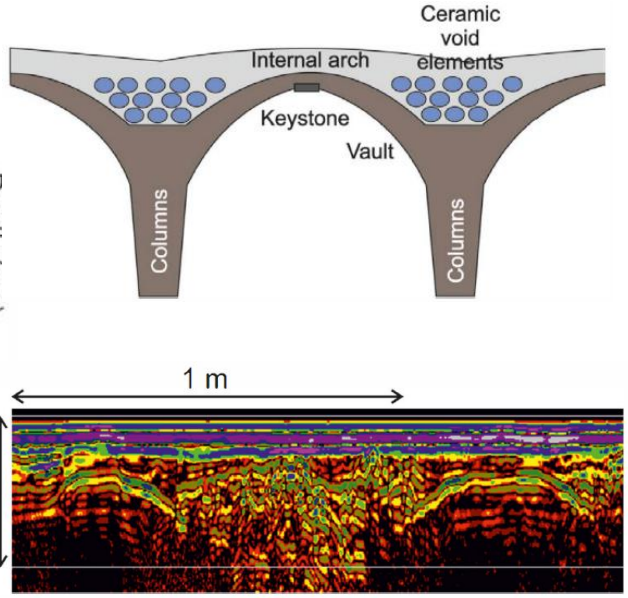
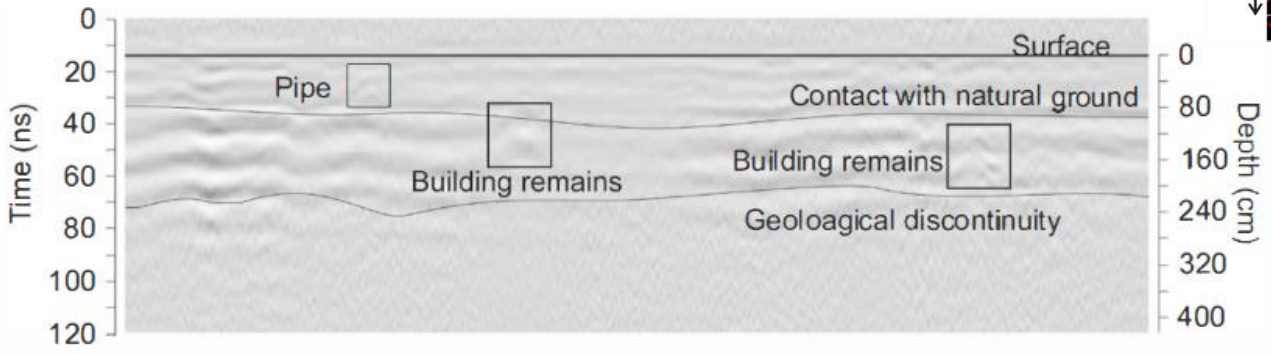
Historical Buildings







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Historical Buildings

Saintenoy et al. (2014) presents the GPR evaluation of the XIV-century Charterhouse of Bourgfontaine in Paris (France). It is a Carthusian monastery of Bourgfontaine, which represented a major foundation, with approximately 24 brothers living in separate cells. Two GPR surveys (225 and 250 MHz) were carried out: the first, in the area of the chapel behind the church, the second, in a rectangular zone of 30 m × 50 m in the great cloister. All the data were processed as a 3D cube and the results give clear evidence of regular structures, allowing for interpretation as three monastic cells and foundations of part of the great cloister.

Saintenoy, A., Rejiba, F., Leger, E., Bonde, S., Maines, C., "Ground penetrating radar prospection at the charterhouse of Bourgfontaine," Proc. 15th International Conference on Ground Penetrating Radar (GPR 2014), Brussels, Belgium, 30 June – 4 July 2014: 83-86, doi: 10.1109/ICGPR.2014.6970390.

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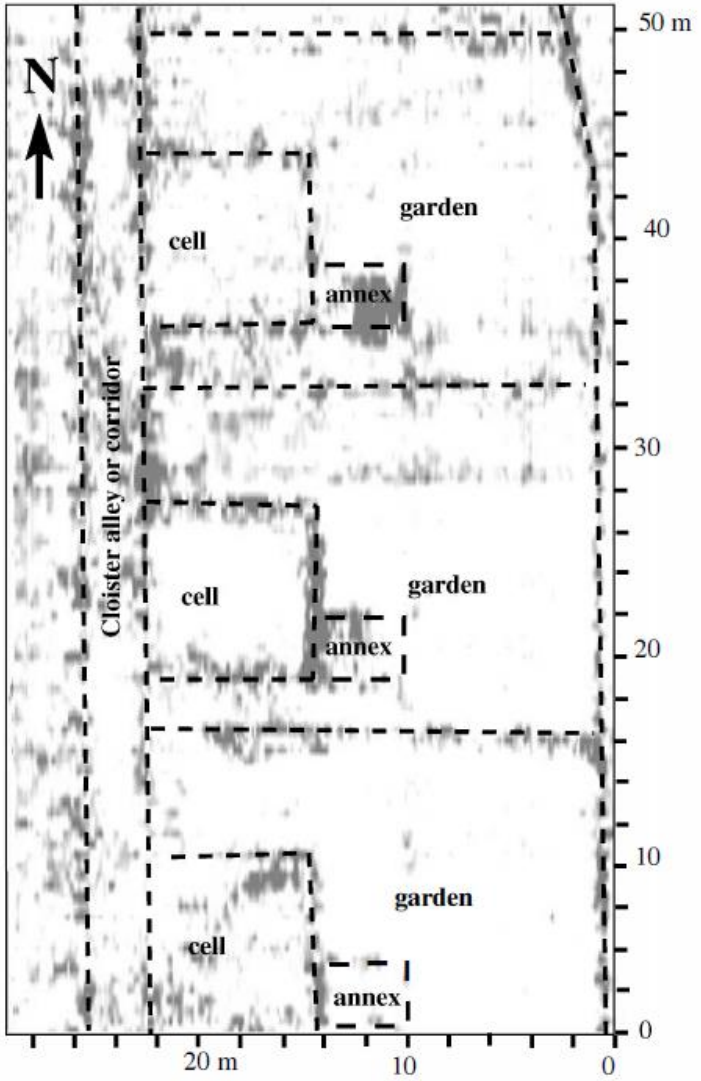
Historical Buildings



Saintenoy, A., Rejiba, F., Leger, E., Bonde, S., Maines, C., "Ground penetrating radar prospection at the charterhouse of Bourgfontaine," Proc. 15th International Conference on Ground Penetrating Radar (GPR 2014), Brussels, Belgium, 30 June – 4 July 2014: 83-86, doi: 10.1109/ICGPR.2014.6970390.

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Historical Buildings

Persico et al. (2016a,b) presents a GPR case study of the XVI-century Saint John's Co-Cathedral in Valletta (Malta). The study shows that the well-known and commonly-adopted method of the diffraction hyperbolas, for the estimation of the propagation velocity, is not always reliable. As an alternative, a sequential migration with progressively lower trial propagation velocities was proposed and successfully used. Several tombs were detected and located in the subsurface of the main nave of the church.

Persico, R., Pajewski, L., D'Amico, S., Pérez-Gracia, V. 2016a. Ground-Penetrating Radar prospection at the Jesuits' church in Valletta, Malta. 22nd European Meeting of Environment and Engineering Geophyscis - Near Surface Geophysics 2016, 4-8 September, Barcelona, Spain, pp. 1-4, doi: 10.3997/2214-4609.201602031.

Persico, R., Matera, L., D'Amico, S., Borg, R.P., Galea, P. 2016b. Integrated GPR and passive seismic investigations at cultural heritage sites: case studies in Malta. Proc. 16th International Conference on Ground Penetrating Radar (GPR 2016), Hong Kong, 13-16 June, pp. 1-5, doi: 10.1109/ICGPR.2016.7572608.

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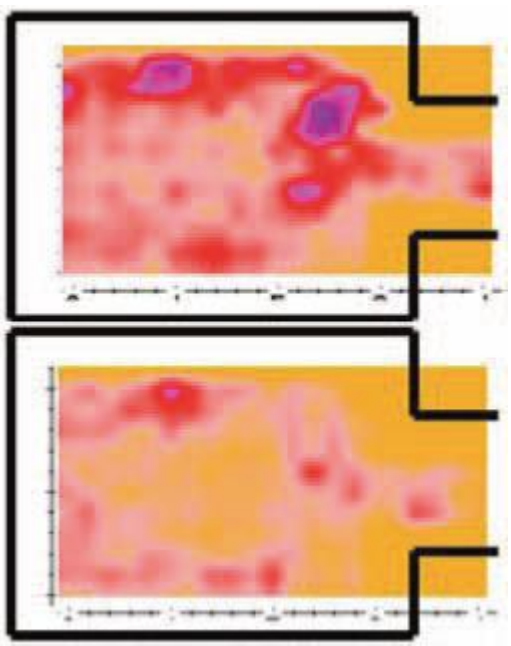
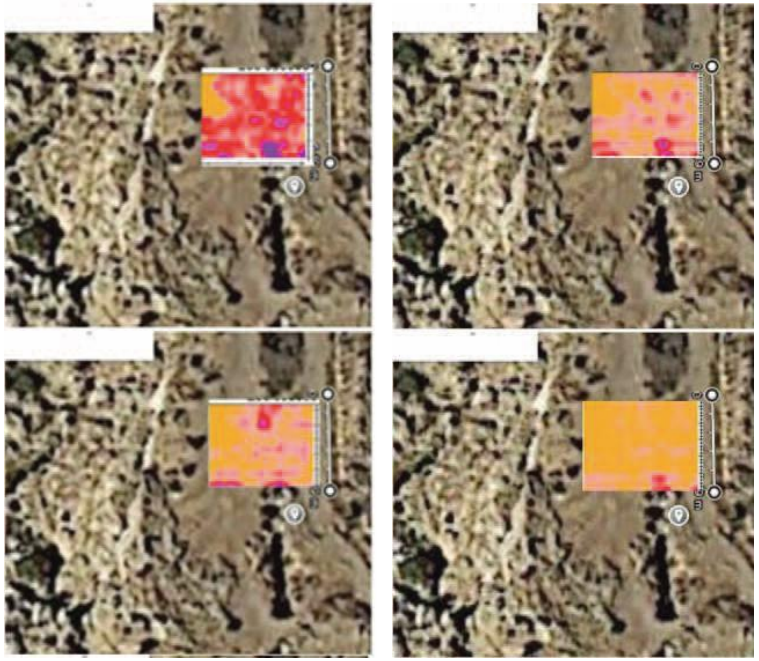
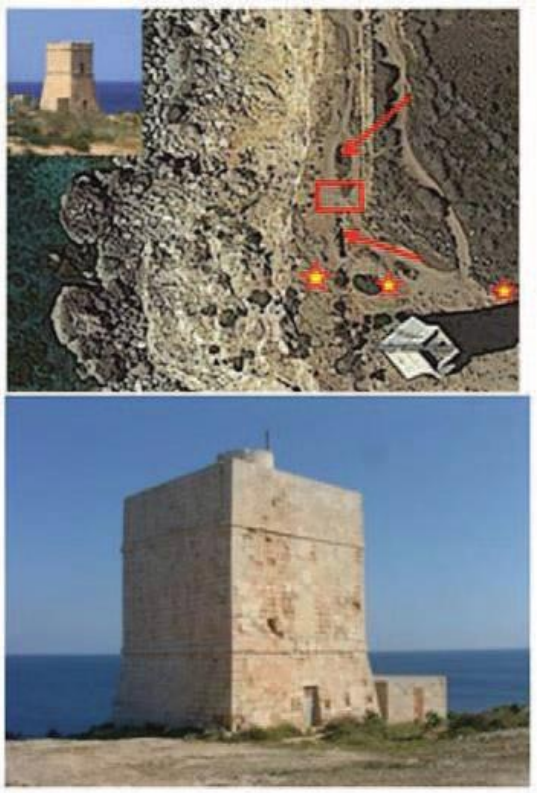
Historical Buildings







Persico, R., Pajewski, L., D'Amico, S., Pérez-Gracia, V. 2016a. Ground-Penetrating Radar prospection at the Jesuits' church in Valletta, Malta. 22nd European Meeting of Environment and Engineering Geophyscis - Near Surface Geophysics 2016, 4-8 September, Barcelona, Spain, pp. 1-4, doi: 10.3997/2214-4609.201602031.

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Historical Buildings

Kadioglu et al. (2014) presents a GPR study of the XVII-century Keciova Mosque of Casbah Algiers, in Algeria.
A RAMAC CU II GPR system and a 250 MHz shielded antenna have been employed inside of the Mosque including the Cathedral and inside of the burial chambers under the Cathedral Site. After applying standard 2D and 3D imaging techniques, the following results were obtained: the base floor including corridors, buried remains under the first ground level between 5.0-7.0 m in depths, and a spectacular protected buried old mosque structures under the second ground level between 9.0-12.0 m in depths.

Kadioglu, S., Kadioglu, K., Deniz, K., "Ground penetrating radar and micro raman spectroscopy in Keciova Mosque Casbah-Algiers (Algeria)," Proc. 15th International Conference on Ground Penetrating Radar (GPR 2014), Brussels, Belgium, 30 June – 4 July 2014: 50-53, doi: 10.1109/ICGPR.2014.6970383.

Kadioglu, S., Kadioglu, K., Deniz, K., Akyol, A., "3D Monitoring under the Keciova Mosque (Casbah-Algier, Algeria) with Ground Penetrating Radar Method ," EGU General Assembly 2014, 27 April – 2 May, Vienna, Austria, article ID EGU2014-9575.

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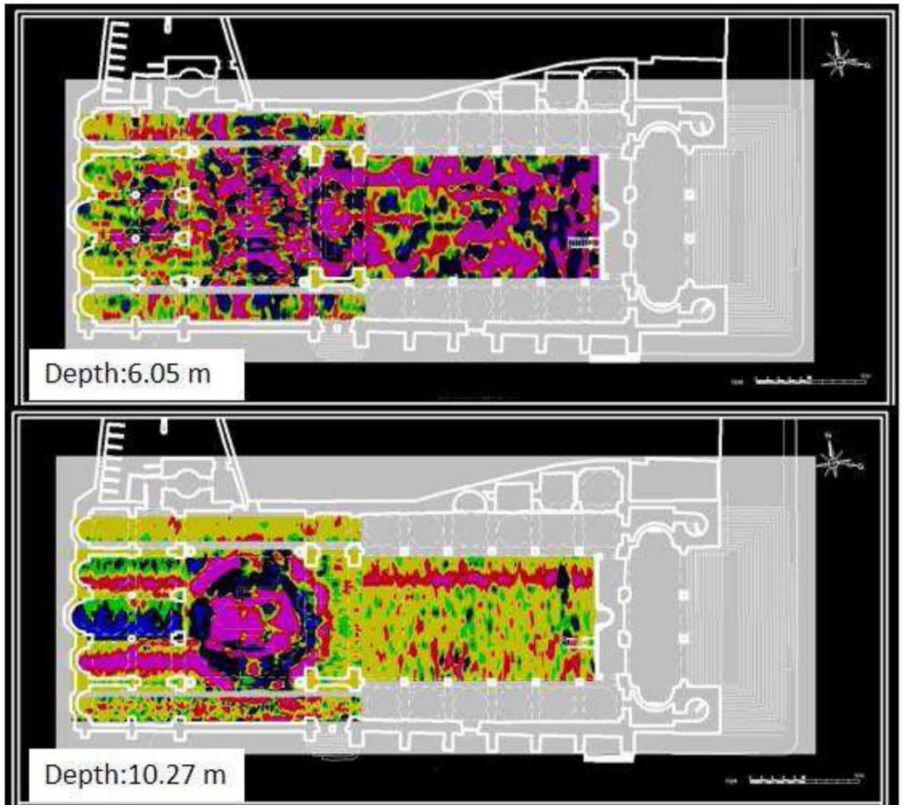
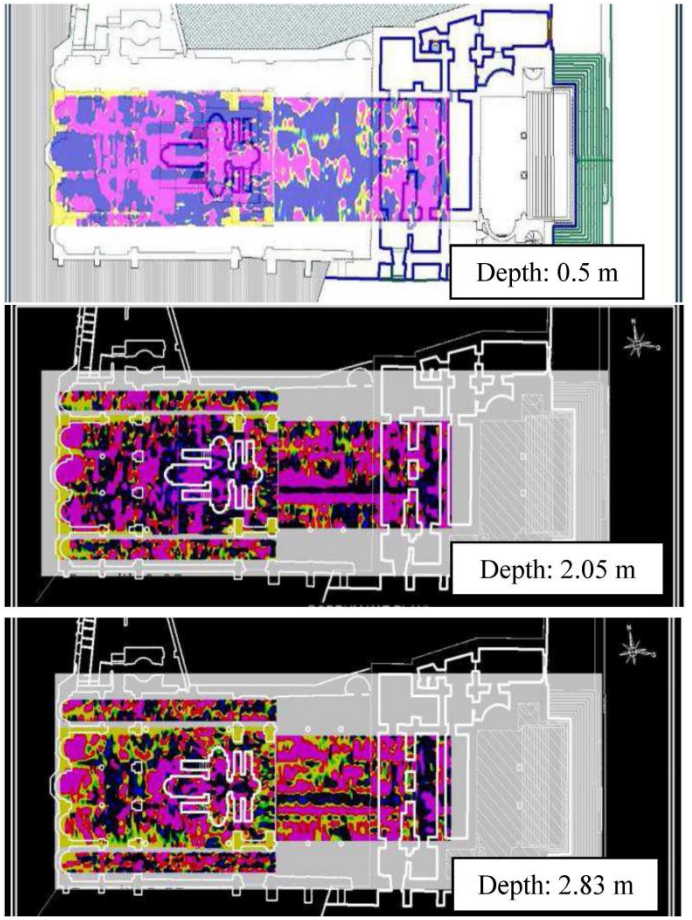
Historical Buildings





Kadioglu, S., Kadioglu, K., Deniz, K., "Ground penetrating radar and micro raman spectroscopy in Keciova Mosque Casbah-Algiers (Algeria)," Proc. 15th International Conference on Ground Penetrating Radar (GPR 2014), Brussels, Belgium, 30 June – 4 July 2014: 50-53, doi: 10.1109/ICGPR.2014.6970383.

Kadioglu, S., Kadioglu, K., Deniz, K., Akyol, A., "3D Monitoring under the Keciova Mosque (Casbah-Algier, Algeria) with Ground Penetrating Radar Method ," EGU General Assembly 2014, 27 April – 2 May, Vienna, Austria, article ID EGU2014-9575.

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Historical Buildings

Santos-Assunçao et al. (2015) presents the GPR assessment of columns in three different places of the XX-century modernista Hospital de la Santa Creui Sant Pau in Barcelona, Spain. The study of the church denotes that the columns are masonry structures with four metallic reinforcements along the shaft. The analysis carried out in the pavilions highlights differences between two types of masonry columns: some of them are built with regular arrangement of bricks and seem to be solid structures; others have a metallic pipe (a rain drainage tube) in the centre of the structure, and the inner elements are most likely portions of bricks with a shape similar to a triangles.

Santos-Assunçao, S., Gonzalez-Drigo, R., Pérez-Gracia, V. 2015. GPR assessment of columns in the pavilions and the church of the Modernista Building Sant Pau Hospital, in Barcelona. Proc. Near Surface Geoscience, 21st European Meeting of Environmental and Engineering Geophysics, 6-10 September 2015, Turin, Itay, doi: 10.3997/2214-4609.201413674.

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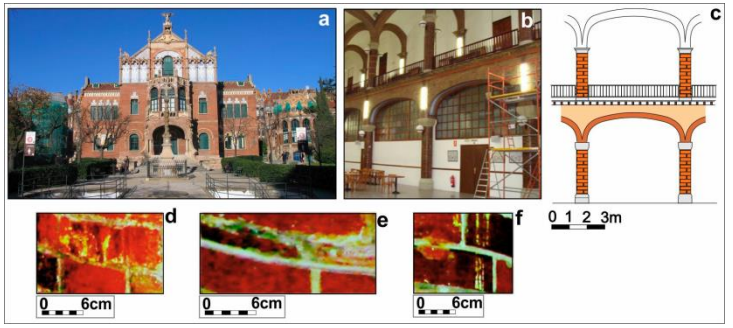

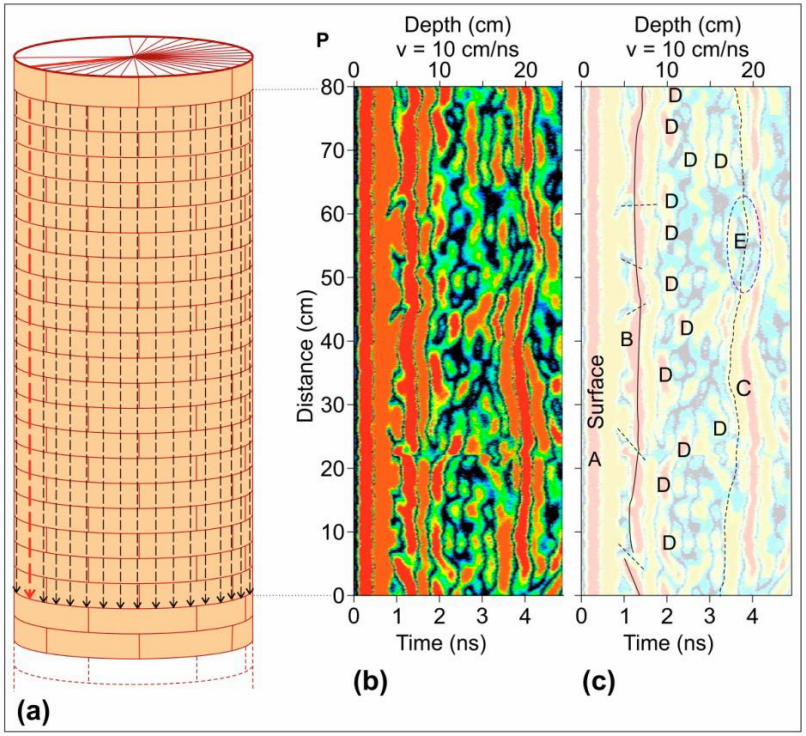

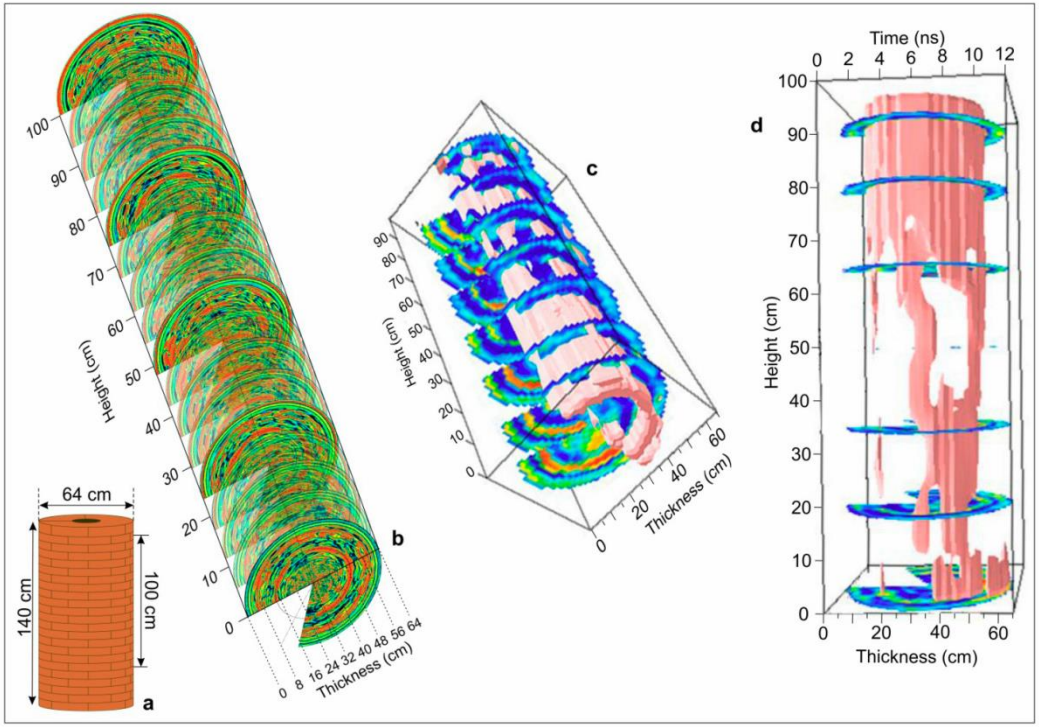

Santos-Assunçao, S., Gonzalez-Drigo, R., Pérez-Gracia, V. 2015. GPR assessment of columns in the pavilions and the church of the Modernista Building Sant Pau Hospital, in Barcelona. Proc. Near Surface Geoscience, 21st European Meeting of Environmental and Engineering Geophysics, 6-10 September 2015, Turin, Itay, doi: 10.3997/2214-4609.201413674.

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STSM, Books and Proceedings

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STSM

*S. Santos Assuncao, K. Dimitriadis, "STSM 2: **The Preservation of the Tholos Tomb of Acharnon**," Short Term Scientific Missions and Training Schools – Year 1, L. Pajewski & M. Marciniak; Eds., Publishing House: Aracne; Rome, Italy, May 2014; ISBN 978-88- 548-7225-7 pp. 46-53.*

An extensive geophysical survey was carried out in a very important Monument of the Hellenic Cultural Heritage, the Tholos Tomb of Acharnon. In this STSM, the unknown thickness of the walls had to be determined; results were plotted using circular radargrams. Discontinuities in the radargrams may be associated to fissures or voids, indicating internal and external damages. A combination of GPR with electrical resistivity tomography could allow us to perform a more accurate data interpretation. The vibrations in the Tomb could be quantified by using seismic measurements and the endoscopy was used to confirm the thickness of the building walls.

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STSM

P. De Smedt, I. Trinks, "STSM 4: ***Reconstructing Prehistoric Environments at Stonehenge with Multiple Electromagnetic Survey Methods****" Short Term Scientific Missions and Training Schools – Year 1, L. Pajewski & M. Marciniak; Eds., Publishing House: Aracne; Rome, Italy, May 2014; ISBN 978-88- 548-7225-7 pp. 64-76.*

Datasets from different multichannel GPR and electromagnetic survey systems will be compared and jointly interpreted. The different datasets that were processed, analysed and compared were data from 1) a multireceiver electromagnetic induction (EMI) survey, and 2) a 3D ground-penetrating (GPR) survey collected. The multireceiver EMI data were collected with a Dualem- 21s. The 3D GPR data, gathered with a MALÅ Imaging Radar Array (MIRA) system in motorized configuration.

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Books and Chapter Books

1) A. Benedetto and L. Pajeswski, "Applications of GPR in Association with Other Non-destructive Testing Methods in Surveying of Transport Infrastructure," Civil engineering applications of Ground Penetrating Radar, Publishing House: Springer International, April 2015, e-book ISBN: 978-3-319-04813-0, hardcover book ISBN: 978-3-319-04812-3, DOI: 10.1007/978-3-319-04813-0.

- *Ch. Inspection Procedures for Effective GPR Surveying of Buildings.*

2) Da Silva, L.M., Rodrigues, H., Gaspar, F., "Nondestructive Techniques for the Assessment and Preservation of Historic Structures," Publishing House: CRC Press/Balkema – Taylor & Francis Group. October 2017. ISBN 9781138710474 - CAT# K32217.

- *Ch. 8. Applications of GPR in the study of cultural heritage: examples of the ability of the method in assessing different features.*
- *Ch. 12. Optical and Electromagnetic Sensing for the Inspection and Characterization of Ancient Masonry Arch Bridges.*
- *Ch. 13. Ground-Penetrating Radar for Archaeology and Cultural-Heritage Diagnostics: Activities Carried Out in COST Action TU1208.*
- *Ch. 14. 3D Reconstruction of the Roman Site Aquis Querquennis by means of TLS and GPR methods.*
- *Ch. 15. Earthquarkes, Tsunamis and Harbours: A Geoarchaeological GPR- Based Approach for Depicting the Spatial Characteristics of Human Structures and Natural Hazards in Ancient Falasarna Harbour.*
- *Ch. 16. Ground-Penetrating Radar for Nondestructive Structural Imaging of Ancient Sculptures.*

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Books and Chapter Books

3) B. Riveiro and M. Solla, "Non-Destructive Techniques for the Evaluation of Structures and Infrastructures,". Publishing House: CRC Press/Balkema – Taylor & Francis Group. April 2016. Book Series: "Structures and infrastructures;" e-book ISBN: 978-1-315-68515-1; hardcover book ISBN: 978-1-138 02810-4; DOI: 10.1201/b19024-1.

- *Ch. 14. Non-Destructive Techniques Applied to Ancient Masonry Bridges Assessment: Structural Diagnosis and Geometric Modeling.*

Proceedings of Action's Meetings

1) F. Soldovieri, Project 4.1 "Applications of GPR and Other Non-Destructive Testing Methods in Archaeological Prospecting and Cultural Heritage Diagnostics" State of the Art and Open Issues. Proc. of the First Action General Meeting | Rome, IT, July 2013, L. Pajewski & A. Benedetto, Eds., Publishing House: Aracne, 2nd Edition, ISBN 978-88-548-7221-9, pp. 155-164.

2) S. Santos-Assunçao, K. Dimitriadis, Y. Konstantakis, V. Pérez-Gracia, E. Anagnostopoulou, M. Solla, H. Lorenzo, "Non-Destructive Assessment of the Ancient Tholos Acharnon Tomb" (Contribution to Project 4.1), Proc. of the Second Action General Meeting | Vienna, AT, April-May 2014, L. Pajewski & A. Benedetto, Eds., Publishing House: Aracne, ISBN 978-88-548-7224-0, pp. 323-333.

3) A. Alani, K. Banks, "Applications of Non-Destructive Methods (GPR and 3D Laser Scanner) in Historic Masonry Arch Bridge Assessment" (Contribution to Project 4.1), Proc. of the Second Action General Meeting | Vienna, AT, April-May 2014, L. Pajewski & A. Benedetto, Eds., Publishing House: Aracne, ISBN 978-88-548-7224-0, pp. 334-346.

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Proceedings of Action's Meetings

4) D. Ene, "Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf – Perspective for the Tu1208 Cost Action," Proc. of the Second Action General Meeting | Vienna, AT, April-May 2014, L. Pajewski & A. Benedetto, Eds., Publishing House: Aracne, ISBN 978-88-548-7224-0, pp. 384-389.

5) K. Dimitriadis, "GPR in the Preservation of Cultural Heritage" Contribution to Project 4.1, Proc. of the Third Action General Meeting | London, UK, March 2015, L. Pajewski, A. Benedetto, A. Alani, S. Lambot, Eds., Publishing House: Aracne; ISBN 978-88-548-8486-1.

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Int. Journals	*Proc. Conferences*	*STSM*	*Ch. Books*	*Proc. Action's Meetings*
4	14	2	8	5
TOTAL: 33				

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COST Action TU1208
Civil Engineering Applications of Ground Penetrating Radar

An overview on the studies carried out by Action Members in the field of Archaeology and Cultural- heritage

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