

Archaeoacoustic Approach to the Rotunda in Bény

Irén Lovász, Paolo Debertolis

IRÉN LOVÁSZ, PhD is an associate professor in the Institute of Arts Studies and General Humanities at KRE University in Budapest, Hungary. Her research has included ethnomusicology, anthropology of religion and music, sacred communication. She is also a professional singer, applying traditional singing in voice therapy.

PAOLO DEBERTOLIS, M.D., aggregate professor at Department of Medical Sciences, University of Trieste (Italy), President of Super Brain Research Group (*)

ABSTRACT: We would like to draw the attention to a medieval sacred place in Central Europe in the Carpathian basin, where unusual sound phenomena can be experienced. We focus our research on the „12 Apostoles’ Rotunda” of *Bény*. The settlement used to belong to the Hungarian Kingdom for centuries during the Middle Ages and also continuously until the first part of the 20th century. Now it is situated in the southern part of Slovakia. Recent studies suggest that the rotunda was already built by the 10-11th century, which raises more questions about who built it and for what purpose. The unique feature of the Rotunda are the 12 mysterious vaulted niches within. Each of these niches strengthens different resonances, which gives a unique sound to the human voice there, according to our hypothesis they were very probably tuned on purpose. In 2016 and 2017 fieldwork was undertaken to test the rotunda’s archaeoacoustic and resonant properties. Equipment, methods, results with our conclusion are described in this paper.

KEYWORDS: acoustics, resonance, rotunda, niches, medieval, Central Europe

Introduction

We would like to draw the attention to a special early medieval sacred space of Central Europe in the Carpathian basin, where unusual sound phenomena can be experienced. We focus our research on the 12 Apostoles’ Rotunda in *Bény* (Bína). The settlement used to belong to the Hungarian Kingdom for centuries during the Middle Ages and also continuously until the first part of the 20th century. Now it is situated in the southern part of Slovakia, closed to the present Hungarian border. The settlement is populated mostly by Hungarians

(90%) belonging to ethnic minority nowadays.

According to the previous concepts on the origin of the building, it was purportedly built at the beginning of the 13th Century¹, together with the Premontrei Monastery and Abbey in the neighborhood.



Fig. 1 – The location of Bény (*Bína*) in Slovakia today.

(*) Note. SB Research Group (SBRG) is an international and interdisciplinary team of researchers, researching the archaeoacoustic properties of ancient sites and temples throughout Europe and Asia (www.sbresearch-group.eu).

¹ Cervers –Molnár Vera: A középkori Magyarország rotundái. Akadémiai Kiadó, Budapest, 1972. 39.



Fig. 2 – The rotunda together the abbey placed in front of it.



Fig. 3 – Some of the 12 niches within the Rotunda

Recent studies however, suggest that the rotunda was built already in the 10-11th century,² which raises more questions about who built it and for what purpose? There is no consensus as archaeologists and art historians have different theories. The Rotunda uniquely features *12 mysterious vaulted niches*. Each of the 12 niches strengthen different resonances, which give a unique sound to the human voice there. All of them are little different in size, and according to our hypothesis they were very probably tuned on purpose.

There is a rumor in the village, shared also by the former local priest: “The niches are tuned as if you sit in the first one from the South and put your ear to the wall, you hear the lowest sound, and at the last one, from

the Northern one you can hear the highest sound.”

Our hypothesis is that there was probably a definite awareness of resonance and the conscious application of artificial niches into the architectural construction in order to improve sound quality thus serving spiritual purposes, since „niches, recesses or alcoves were used as natural resonators”³ in medieval architectural construction.

After discovering its marvelous mysterious acoustics while giving a solo concert in the neighboring abbey, initial fieldwork was carried out in 2013. Oral history as an anthropological method of study was used and local people were interviewed to understand local legends relating to the rotunda. A priest now in service in Bratislava, who was born in Bény and spent all his childhood in the village said that sitting and singing in the niches to find which of them his feet could reach the floor, was his favorite activity as a small boy.

Unfortunately, we discovered the rotunda’s acoustics had changed after some constructions, reconstructions and renovations were carried out during the centuries, as described bellow.

In 2016 and 2017 fieldwork was undertaken in partnership with Irén Lovász and Paolo Debertolis to test the rotunda’s archaeo-acoustic and resonant properties.

Historical Background

2 Szilágyi András: A Kárpát-medence rotundái és centrális templomai, Semmelweis kiadó, Budapest, 2008. 249.

Németh Zsolt: A Kárpát-medence legkülönösebb középkori templomai, BKL Kiadó, Szombatheely, 2017. 103-119.

Sabasošova, Elena – Havlik, Marian: Rotunda Dvanastich Apostolov v Bini- dokumentácia odkrytých murív s vyhodnotením nálezov. 2010. Sabasošova, Elena – Havlik, Marian: Rotunda

Dvanastich Apostolov v Bini In: Valeková, Anna (ed) :Ranostredovekásakrálna architektúra Nitrianskeho kraja: Zborník zo seminára a katalóg ku výstave. Nitra, 2011.

³ Reznikoff, Iegor: *The Evidence of the Use of Sound Resonance from Palaeolithic to Medieval times*, in: *Archaeoacoustics*, Lawson, G. and Scarre, C. eds. University of Cambridge, Cambridge, 2006, 80.

Bény (Bína) is located on the right side of the river Garam, 17 kms North from Esztergom, the first medieval capital of the Hungarian Kingdom. *Esztergom* is 46 kilometres northwest of the capital Budapest. It lies on the right bank of the river Danube, which forms the border with Slovakia there today. Its cathedral, the Esztergom Basilica is the largest church in Hungary. Esztergom is one of the oldest towns in Hungary. The first people known by name were the Celts from Western Europe, who settled in the region in about 350 BC. A flourishing Celtic settlement existed there until the region was conquered by Rome. Thereafter it became an important frontier town of Pannonia, known by the name of *Salvio Mansio*, or Solva of the Roman Empire. Slavic people immigrated into the Pannonian Basin at about 500 AD. The Magyars (Hungarians) entered the Pannonian Basin/ Carpathian Basin in 896. In 960, the ruling prince of the Hungarians, Géza, chose Esztergom as his residence. His son, Vajk, who later came to become Saint Stephen, the first king of Hungary, was born here around 969-975. In 973, Esztergom served as the starting point of an important historical event: during Easter of that year, Géza, the ruling prince sent a committee to the international peace conference of Emperor Otto I in Quedlinburg. He offered peace to the Emperor and asked for missionaries. And it might be a crucial point for us!

There was a church also built by the German missionaries from around Passau between 973- 1000 in Esztergom. The center of the hill was occupied by a Basilica dedicated to St. Adalbert who, according to legend, baptized St. Stephen. Stephen's coronation took place in Esztergom on Christmas Day 1000.

Bény

After the importance of the city of Esztergom in Hungarian History, *Bény* should be considered as an important small village, especially given it is located 17 kilometers North of Esztergom on the eastern side of the river Garam.

Historical records first mention the village, written as *Byn* in 1135. Earlier the Romans built a fortress here, and Emperor Marcus Aurelius wrote his famous diary in this region in 173. According to local knowledge, proved by archeological excavations, Bény used to be the Northern *limes*, border of the Roman Empire. Later, King Stephen, the first king of Hungary, gave the region to Bény, son of Hont. It was already Géza, the father of St. Stephen, who invited the Kraut knights, Hont and Pázmány to stay in Hungary on their way to the Holy Land.⁴ It is also possible that the rotunda was built by Byn himself or by his descendants at the centre of genus for the leader.⁵

The great system of escarp or redoubt with 5 kilometers in its inside diameter, was the biggest and strongest that time in Europe. Finally it lost its original function during the 11-12th centuries, it was left empty. But one can still find remains of it around the village, about 1 kilometer from the rotunda. This military post might has been the gathering basis of the army of St. Stephen the first Hungarian king, before going against the tribes of the pagan leader, Koppány. Very probably it was the place where Stephen I was given his *first sword* as a symbol of his puberty-ritual or of age of discretion as part of an ancient *rite de passage* ages 21 in 998 AD. (There was a monument erected a few years ago in front of the abbey for the memory of this historical fact by the proud local citizens of Bény). During the time of early Christianity every 10 villages was ordered to build a church and several rotundas were built in this time. According to some presuppositions, one of them might has

⁴ Szilágyi 249.

⁵ Szilágyi, 249.

been the rotunda of Bény. But we do not share this idea. We argue in accordance with the latest literature⁶ that it was already built at the end of the 10th century.

The Rotunda

In 1217 the Premontre Abbey monastery was founded in Bény in the Romanesque style. An earlier built rotunda stands in front of the abbey today. The patriarch of the rotunda is the 12 Apostles. (Though it easily might have got the name of 12 apostles afterwards).



Fig. 4 – The rotunda today

During the Turkish invasion of 16-17th Century the rotunda was damaged. The village got empty, uninhabited. The rotunda became the *filia* of the neighboring Kéménd at the beginning of the 18th Century.⁷ In 1755 it was reconstructed in the baroque style, however it was given a new interior, design and ornaments. Much of the early medieval roman style was lost, for example a new baroque window was cut into the wall which would have originally been closed. During World War I. in 1918, Czechoslovak troops occupied the area, and the region became part of Czechoslovakia. Between 1938 and 1945 Bény once more became part of Hungary. Then until 1990, it was

part of Czechoslovakia. Since then it has been part of Slovakia and officially called Bína.

There was bomb damage during World War II, which revealed the medieval walls behind the baroque facade and an additional room was added to the south of the rotunda in 1945.



Fig. 5 - The Rotunda after the Second World War.

From 1961- 1978, a big archaeological excavation and reconstruction was undertaken by Slovak archaeologists.⁸ All traces of the baroque design including its windows and crude electric wires were removed. More recently, Slovak archaeologists, Elena Sabadosova-Marian Havlik undertook archaeological studies and reconstructions between 2006- 2012,⁹ was also supported by the Hungarian ministry of culture. After the last renovation the so called “original” structure was finally reconstructed: The ground became 40 cm deeper, with all the niches equally positioned 43cm above ground level. Was this the original case or not? If we listen to the memory of the priest who grew up playing and sitting in these niches, then we must say no.

The structure of the rotunda reminds us also of Saint Donatus in Zara, Dalmatia (9th cc). Although this one in Bény is much smaller.

⁶ Sabadosova-Havlik 2011, 141, Németh Zsolt 2017, 103-119.

⁷ Haiczl, 95.

⁸ The first excavation was led by Alojz Habovstiak, 1963, 1978.

⁹ Sabadosova, Elena – Havlik, Marian: 2010, 2011.

The size of the rotunda: inner diameter: 720 cm, 12 niches: 80-82 cm, the excedra 360 cm.

In this structure there was no separate sanctum, but the whole rotunda itself served as such. It either shows that there was a different type of Christianity in the region before the 10th century or the Latin liturgy and proxemic attitudes changed so radically by the first millennium and consequently there is a lack of knowledge about. In this region during the 5-6th century, Arian Christianity was the main religion and still had some power among the *avars* after the 7th century¹⁰



Fig. 6 – The Rotunda's interior

As far as the structure and shape of the rotunda in Bény is concerned, it is suitable to serve ritual and ceremonial purposes of special democratic communities with equal members. All the members of the community (lets say monks) could see and hear the others while looking and turning to the middle, to the central point of the rotunda, or to the leader of them, who might have stood or

set in the exedra, in the 13th and greatest niche. It might also have served as a Chapter –house, in which monks met daily to discuss business and to hear a chapter of monastic rule. But it should be noted that the acoustics of this rotunda supports chanting, singing, and not the spoken voice!

In this respect, it differs from churches, basilicas with naves, typical of the 2nd millennium. There is also a presupposition about using the special acoustic power of the space of the rotunda, for healing, initiating ritual purposes” where the human voice had an important role. Since medieval monks used magical practices and techniques to enter altered states of mind, and likewise helping others to achieve this, something very different from normal daily experiences.”¹¹

The Shape of the Rotunda

The rotunda has historical and architectural value, its shape was widespread in medieval times. A great number of parochial churches were built in this form in the 9th to 11th centuries in Central Europe and examples can be found throughout Hungary, Slovakia, Poland, Croatia, Austria, Bavaria, Dalmatia, Germany, and the Czech Republic. It was believed to be a structure descending from the Roman Pantheon, however, it is rare to find such examples in former Roman territories. They are far more common in Central Europe. (Note: Bény is located at the Northern border of the Roman Empire). Generally its size was 6–9 meters inner diameter and the apses were directed toward the east, sometimes 3 or 4

¹⁰ Németh Zsolt, 118.

¹¹ Németh, Zsolt, 121.

apses were glued to the central circle and this type has relatives in the Caucasus.¹²

There are about one hundred rotundas in the Carpathian Basin. The greatest most recent summary of them was written by a Hungarian author who undertook a deep study of their origin along with related archetypical buildings of the type.¹³ Several types of rotundas are found in the Carpathian Basin, within the former boundaries of Medieval Hungary. Many of them still stand today. In many places the ancient foundations have been excavated and conserved. Rotundas of six apses, a most interesting form, are found in Hungary, in Ukraine and several places in Armenia. There is no possibility here of mentioning all the archetypical examples of round shaped sacred architecture of the world from The Church of the Rotunda in Thessaloniki, built as the "Tomb of Galerius" in 306, to the Hall of Prayer for Good Harvests, the largest building in the Temple of Heaven, construction completed on 1420 during Yongle Emperor who also constructed Forbidden City of China, Beijing.

There is much literature on ancient buildings from all over the world that discuss the significance of the rotunda's shape. To reconstruct sonic and spatial experiences of the past, a new multidisciplinary collection of essays explores the intersection of liturgy, acoustics, and art in the churches of

Constantinople, Jerusalem, Rome and Armenia.¹⁴ Other ancient rotundas and round shaped sacred spaces are also considered, from the shape of Zuart'noc', and its relation to Syrian and Mesopotamian monuments, of the same type to its obvious prototype in the martyria of the Holy Land, above all the Anastasis Rotunda. Completed by 336 to shelter the traditional site of Christ's burial and resurrection, this structure formed the focal point of Christian Jerusalem, and indeed, of medieval Christendom more generally."¹⁵ The book studies the structure of the rite, revealing the important role chant plays in it, and confronts both the acoustics of the physical spaces and the hermeneutic system of reception of the religious services. The result is a rich contribution to the growing discipline of sound studies and an innovative convergence of the medieval and the digital. Pentcheva made remarkable studies on the acoustics of Hagia Sofia, the cathedral of Constantinople itself.¹⁶

Whatever the origin of the rotunda form, the symbolic meaning of the archetypical round shape is related to the universal meaning of perfect completeness, wholeness, oneness, unity, deity. It also expresses power and nobility.¹⁷ In rotundas and round shape sacred sites it is possible to feel the positive energy and esthetic effect on the mind and psyche, as the ancient Greek authors have contemplated.¹⁸

¹² First main publication on the topic in Hungarian: Cervers –Molnár Vera: A középkori Magyarország rotundái. Akadémiai Kiadó, Budapest, 1972.

¹³ Szilágyi András: A Kárpát- medence rotundái és centrális templomai, Semmelweis kiadó, Budapest, 2008.

¹⁴ Pentcheva V.,Bissera (ed.): Aural Architecture in Byzantium: Music, Acoustics, and Ritual, Routledge 2017.

¹⁵ Pentcheva V.,Bissera: Introduction in Pentcheva V.,Bissera(ed.), 11.

¹⁶ Pentcheva V.,Bissera : Hagia Sophia: Sound, Space, and Spirit in Byzantium, Pennsylvania State University Press, 2017, <http://hagiasophia.stanford.edu> 2. (2018.01.03.)

¹⁷ Szilágyi , 144

¹⁸ see: Marcus Vitruvius Pollio: de Architectura, inLacus Curtius: Vitruvius on Architecture,

Materials and Methods

For recording two dynamic high-end microphones both extended over the audible band (Sennheiser MKH 8020, response frequency 10Hz - 60.000Hz) with shielded cables (Mogami Gold Edition XLR) and gold-plated connectors together with a digital portable recorder with a maximum sampling rate of 192KHz (Tascam DR-680 of TEAC Group) at 24bit were used. The microphones were placed in a number of positions in the Rotunda, but the best recordings were obtained when the mikes were located in the centre. Before recording a spectrum analyser Spectran NF-3010 from the German factory Aaronia AG, was used to detect any electromagnetic phenomena present which could influence the results. Praat program version 4.2.1 from the University of Toronto and Audacity open-source program version 2.1.2 for Windows and Linux were used to analyze the various recorded audio tracks.

The rotunda was tested by male and female voice from several locations; within every niche and within the central area of the Rotunda. No electronic or synthetic tones were used for testing, only the natural voice to recreate as far as possible the original reverberation and resonance. A drum was also used, (its frequency response and extension were identified and used in previous research) using a protocol for testing temples (Debertolis et al. 2012-2017). The music and songs used to test the acoustical properties of the structure ranged from simple tones and musical scales to Gregorian chants and romances of the XIII-XIV centuries. To establish the environmental sound characteristics (infrasound) a recording was made in silence.

Physical phenomena was measured using a Geiger counter to detect radioactivity and UV imaging to detect magnetic fields as these can influence the state of mind. The purpose was to research common characteristics found in ancient “sacred” sites as discovered in our previous research. In fact many medieval structure are built over veryancient sites with peculiar physical characteristics (Debertolis *et al.*, 2011 - 2017). Every aspect of the niche was explored to search for different resonance characteristics.

Results

We observed that all the niches have a different depth, but the same height and distance from the ground. This aspect create a different resonance at different frequencies, so the 12 niches act as the tubes of an organ.

So there is not a singular frequency of resonance, but various frequencies of resonance very good for both male and female voices. The extension of resonance is wide and the result is to amplify all singing voices. But a requirement to achieve this is to have a strong volume. The spoken voice alone does not stimulate the structures resonance, there is just a little reverberation coming from the dome.

In the silence a constant frequency of 20-21 Hz can be heard and is accompanied by two peaks at 48db and 56-57Hz at 50-51db. These frequencies are not found in the surrounding area (Fig. 11). Because similar-characteristics were found at other sacred sites, we have assumed they are most likely originating from a subterranean water source deep below the surface with the vibrations concentrated in the Rotunda. Such frequencies affect the mind creating a sense

Book IV.Chapters 8. http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Vitruvius/5*.html2017. 12.30.)



Fig. 7 – The Sennheiser microphones positioned at the centre of the Rotunda.



Fig. 8 – Every niche was tested by voice and drum.



Fig. 9 – The imaging operation with UV camera

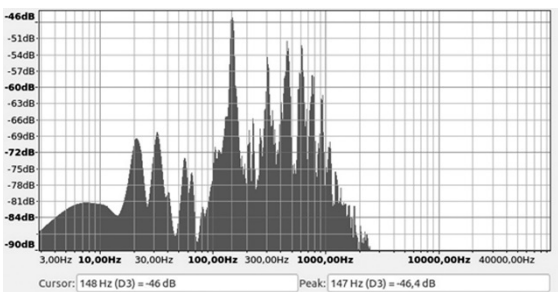


Fig. 10 –During the chanting some harmonics were produced without a single resonance frequency, but with a lot of resonance which acted like an amplifier for the voice.

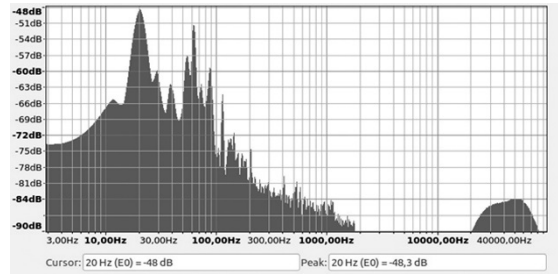


Fig. 11 – The constant peak of underground noise.



Fig. 12 – The surveys inside the rotunda (left) and outside the Rotunda (right). There were a lot of natural magnetic fields on the ground (all electric devices were switched off).

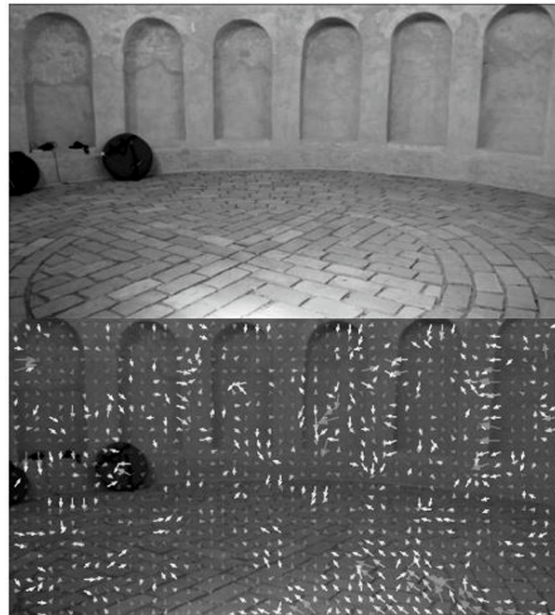


Fig. 13 – The Rotunda's interior; UV image (above) and after software analysis measuring velocimetry of air molecules (below). This shows the presence of small natural torsional magnetic fields inside the Rotunda.



Fig. 14 – Radioactivity - inside the Rotunda is double that of the outside.

of sacredness. Using various devices, the presence of magnetic fields inside the Rotunda was measured to confirm the presence of water. The main power switch which provides electricity to the building was turned off so that accurate measurements of the magnetic fields could be recorded. We discovered a number of magnetic fields inside, but none outside or in the neighboring area (Fig. 12)

By imaging the UV band it was possible to evidence the natural spiral magnetic fields originating from the movement of underground water (Fig. 13). Software analysis was made using Dante Dynamics (Canada) software.

Radioactivity looks very different inside and outside the Rotunda that is contrary to what is found in normal structures. Outside the Rotunda, natural radioactivity slowly swung in a range between 0.08 to 0.14 $\mu\text{Sv/h}$ (microSievert/hour) within a normal range. Inside the Rotunda radioactivity was double that of the outside, around 0.28 $\mu\text{Sv/h}$ (Fig. 14), but below danger level (0.4 $\mu\text{Sv/h}$). There was no difference if the Geiger counter was placed close to or distant from the floor, so we can suppose it was not related to the floors material, but very likely due to the movement of underground water.

Discussion and Conclusion

Analysis was carried out on two separate occasions over two years. No single resonance frequency was found within the structure, rather there several frequencies were obtained. Through sound analysis we found that each of the 12 niches have different resonances which strengthen and enhances the both male and female voices. All niches are different in size and according to our hypothesis they were tuned on purpose. The niches function like organ tubes each with a different resonant frequency. Despite numerous renovations the Rotunda has perfect

acoustics even now. The optimal acoustic effect is achieved if the singer sings in the centre of the chapel, where the reverberation from the dome and the resonance from the niches have the maximum effect. The structure of other rotundas in the region and beyond were compared to that of Bény, none featured the same design feature of 12 niches, which makes it unique. We can therefore conclude the structure was built with an acoustic scope as a sacred temple and its architect had great knowledge of acoustics. We can also assume it was built over an earlier sacred site, because it has some natural phenomena inside which are not found outside. This is typical of very ancient sacred sites we studied in Europe. This along with its acoustical properties make it worthy of broader research from experts in architecture, art history, acoustics, early music, and we hope this can be undertaken in the near future. From our side we can consider these results as preliminary, but perhaps stimulating other researchers to continue the research.

ACKNOWLEDGMENT

We are grateful to the following people for their support, information and help during and/or organising and managing our field-work and study in Bény: Dr. Imre Molnár, (Pozsony/Bratislava), Himler György (Párkány/Sturovo), Tamás Molnár (Pozsony/Bratislava), parish priests: Dean András Nagy, Sándor Kassa, András Szalai, representatives of the local museum and people: Gyula Koczka, Katalin Koczka, Szabolcs Kremmer (Bény), Dr. István Horváth (Esztergom). A sincere thank you to Nina Earl for her support in editing this text. We are grateful to Daniele Gullà, vice-president of Super Brain Research Group (SBRG), for analysing the imaging aspect of the Rotunda.

REFERENCES

- V. Cervers –Molnár: "A középkori Magyarország rotundái. Akadémiai Kiadó", Budapest, 1972.
- I. Ciulisová: Pamiatková obnova Kostola Panny Márie v Bini. Pamiatky a múzeá 4. 1999. 32-36.
- P. Debertolis, H.A. Savolainen: "The phenomenon of resonance in the Labyrinth of Ravne (Bosnia-Herzegovina). Results of testing", Proceedings of ARSA Conference (Advanced Research in Scientific Areas), Bratislava (Slovakia), December, 3-7, 2012, pp. 1133-1136.
- P. Debertolis, N. Bisconti: "Archaeoacoustics in ancient sites" Proceedings of the "1st International Virtual Conference on Advanced Scientific Results" (SCIECONF 2013), Žilina (Slovakia) June, 10-14, 2013, pp. 306-310.
- P. Debertolis, N. Bisconti: "Archaeoacoustics analysis and ceremonial customs in an ancient hypogeum", Sociology Study, Vol.3 no.10, October 2013, pp. 803-814.
- P. Debertolis, G. Tirelli, F. Monti: "Systems of acoustic resonance in ancient sites and related brain activity". Proceedings of Conference "Archaeoacoustics: The Archaeology of Sound", Malta, February 19-22, 2014, pp. 59-65.
- P. Debertolis, D. Gullà, F. Richeldi: "Archaeoacoustic analysis of an ancient hypogeum using new TRV camera (Variable Resonance Camera) technology", Proceedings of the "2nd International Virtual Conference on Advanced Scientific Results" (SCIECONF 2014), Žilina (Slovakia) June, 9 - 13, 2014, pp. 323-329.
- P. Debertolis, N. Bisconti: "Archaeoacoustics analysis of an ancient hypogeum in Italy", Proceedings of the Conference "Archaeoacoustics: The Archaeology of Sound", Malta, February 19-22, 2014, pp. 131-139.
- P. Debertolis, A. Tentov, D. Nicolic, G. Marianovic, H. Savolainen, N. Earl: "Archaeoacoustic analysis of the ancient site of Kanda (Macedonia)", Proceedings of the 3rd Conference ARSA (Advanced Research in Scientific Areas), Žilina (Slovakia), December, 1-5, 2014, pp. 237-251.
- P. Debertolis, F. Coimbra, L. Eneix: "Archaeoacoustic Analysis of the HalSaflieni Hypogeum in Malta", Journal of Anthropology and Archaeology, Vol. 3 (1), 2015, pp. 59-79.
- P. Debertolis, D. Gullà: "Archaeoacoustic analysis of the ancient town of Alatri in Italy", British Journal of Interdisciplinary Science, September, Vol. 2, (3), 2015, pp. 1-29.
- P. Debertolis, M. Zivic: "Archaeoacoustic analysis of Cybele's temple, Roman Imperial Palace of Felix Romuliana, Serbia", Journal of Anthropology and Archaeology, Vol. 3 (2), 2015, pp. 1-19.
- P. Debertolis, D. Nicolic, G. Marianovic, H. Savolainen, N. Earl, N. Risteviski: "Archaeoacoustic analysis of Kanda Hill in Macedonia. Study of the peculiar EM phenomena and audio frequency vibrations", Proceedings of the 4th Conference ARSA (Advanced Research in Scientific Areas), Žilina (Slovakia), November 9-13, 2015, pp.169-177.
- P. Debertolis, N. Earl, M. Zivic: "Archaeoacoustic Analysis of Tarxien Temples in Malta", Journal of Anthropology and Archaeology, Vol. 4 (1), June 2016, pp. 7-27.
- P. Debertolis, D. Gullà: "Preliminary Archaeoacoustic Analysis of a Temple in the Ancient Site of Sogmatar in South-East Turkey. Proceedings of Conference 'Archaeoacoustics II: The Archaeology of Sound', Istanbul (Turkey), Oct 30-31 Nov 1, 2016, pp. 137-148.
- P. Debertolis, D. Gullà: "New Technologies of Analysis in Archaeoacoustics", Proceedings of Conference 'Archaeoacoustics II: The Archaeology of Sound', Istanbul (Turkey), Oct 30-31 Nov 1, 2015, pp. 33-50.
- P. Debertolis, D. Gullà: "Healing aspects identified by archaeo-acoustic techniques in Slovenia", Proceedings of the '3rd International Virtual Conference on Advanced Scientific Results' (SCIECONF 2016), Žilina (Slovakia), June 6-10, 2016, pp. 147-155.
- P. Debertolis, D. Gullà, F. Piovesana: "Archaeoacoustic research in the ancient castle of Groparello in Italy", Proceedings in the Congress "The 5th Virtual International Conference on Advanced Research in Scientific Areas" (ARSA-2016) Slovakia, November 9 - 11, 2016: pp. 98-104.
- P. Debertolis, N. Earl, N. Tarabella: "Archaeoacoustic analysis of Xaghra Hypogeum, Gozo, Malta", Journal of Anthropology and Archaeology, vol.1 no. 5, June 30, 2017. In press.
- P. Debertolis, D. Gullà: "Archaeoacoustic Exploration of Montebello Castle (Rimini, Italy)", Art Human Open Acc J 1(1): 00003, DOI: 10.15406/ahoaj.2017.01.00003.
- P. Debertolis, D. Gullà, H. Savolainen: "Archaeoacoustic Analysis in Enclosure D at Göbekli Tepe in South Anatolia, Turkey", Proceedings in Scientific Conference "5th HASSACC 2017 - Human And Social Sciences at the Common Conference", Slovakia, Žilina, September 25-29, 2017: pp. 107-114.
- A. Habovstiak: Archeologický výskum v Bini. Vlastivedný časopis 12. 1963. 173-177.
- A. Habovstiak: Bina. In: Vyznamné slovanské náleziská na Slovensku. Bratislava, 1978. 23-24.
- K. Haiczl: A bényi prépostság temploma. Galánta, 1937. In: Haiczl K. (ed.): Kakath, Dsigerdelen-Csekerdén, Párkány., 2nd edition.: Párkány és vidéke Kulturális Társulás, 1997. 89-99.
- K. Kozák: Téglából épített körtemplomaink és centrális kápolnánk a XII.-XIII. században. Móra Ferenc Múzeum Évkönyve. 1976-77.
- Z. Németh: A Kárpát-medence legkülönösebb középkori templomai II., BKL Kiadó, Szombathely, 2017. 103-119.
- V. Pentcheva,Bissera(ed.): Aural Architecture in Byzantium: Music, Acoustics, and Ritual, Routledge 2017.
- V. Pentcheva,Bissera : Hagia Sophia: Sound, Space, and Spirit in Byzantium, Pennsylvania State University Press, 2017, <http://hagiasophia.stanford.edu> 2. (2018.01.03.)
- V. Pentcheva,Bissera :The Sensual Icon: Space, Ritual, and the Senses in Byzantium Pennsylvania State University Press, 2010, paper back 2013, www.thesensualicon.com
- I. Reznikoff: The Evidence of the Use of Sound Resonance from Palaeolithic to Medieval times, in: Archaeoacoustics. Lawson, G. and Scarre, C. eds. University of Cambridge, Cambridge, 2006,
- E. Sabasosova, M. Havlik: Rotunda Dvanastich Apostolov v Bini-dokumentácia odkrytých murív s vyhodnotením nálezov. 2010.
- E. Sabadosova, M. Havlik: Rotunda Dvanastich Apostolov v Bini In: Valeková, Anna (ed): Ranostredovekásakrálna architektúra Nitrianskeho kraja: Zborník zo seminára a katalóg ku výstave. Nitra, 2011.
- A. Szénássy: Felvidéki Árpád-kori templomok lexikona. I. A Nyitrai kerület- Szlovákia, Komárom, 2005.
- A. Szilágyi: A Kárpát-medence rotundái és centrális templomai, Semmelweis kiadó, Budapest, 2008. 2nd edition 2009.
- N. Tarabella, P. Debertolis: "Archaeoacoustics in Archaeology", Proceedings in 19th International Conference and Assembly of the Experts of the Foundation Romualdo Del Bianco "HERITAGE FOR PLANET EARTH 2017 - Smart Travel, Smart Architecture and Heritage Conservation and its Enjoyment for Dialogue", Florence, Italy, 11-12 March 2017: 240-246.