

Archaeoacoustics in ancient sites

A new way to analyzing archaeological locations

Paolo Debertolis

Department of Medical Sciences - University of Trieste
Chair of Dental Archaeology
Coordinator of project SB Research Group*
Trieste, Italy
paolo.debertolis@sbresearchgroup.eu

Niccolò Bisconti

Department of Archaeology and Art History
University of Siena
Project SB Research Group*
Siena - Italy

Abstract—Using archaeoacoustics we can analyze ancient sites from another point of view to discover the real purpose of their builders to point out natural phenomena connected with a particular location and the mystic state of visitors. We also present the results from two ancient sites we studied over the last two years in Europe.

Keywords: *archaeoacoustics, ultrasounds; abbye; San Salvatore, Visočica; Bosnia; pyramid; infrasounds; low frequency sounds*

I. ARCHAEOACOUSTICS

Archaeoacoustics is not a new science, it is a new perspective to analyze archaeological sites which sometimes have interesting sound characteristics^[2,6]. It can demonstrate sound occurrences projected by the builders of some structures, and also natural phenomena which can influence the psychological state of a person in a mystic state or during prayers^[2,3,4]. In a previous article we described the resonance phenomenon we found in some archaeological sites^[1]. Using modern digital recording techniques it is now possible to record very clearly non audible sound frequency bands such as ultrasound or infrasound. These bands have a direct effect on the human body without a person being aware of the associated mechanical vibrations. The hypothesis of our research group is that in some archaeological sites considered sacred for thousands of years, there are measurable natural audio phenomena that make the place somewhat more mystical than others.

Following this line of research, we started to test various sacred sites in Europe to assess this hypothesis. We found interesting archaeoacoustics effects at some sites, which included the Cistercian Abbey of San Salvatore in Abbadia San Salvatore in the province of Siena (Italy) and among ruins of medieval monastery/fortress on the top of the Visočica Hill near Visoko in Bosnia-Herzegovina.

II. ULTRASOUNDS, INFRASOUNDS AND AUDIBLE LOW FREQUENCIES

There are a lot of scientific papers that evidence mechanical vibrations have a positive or negative influence on our health and there are several predominant sources of naturally occurring ultrasounds, very low frequency and infrasound found in the environment. Depending on age and gender, humans can perceive sounds in the range of 20hz to 20Khz, in some cases sounds above 14-18Khz are not audible to the

human ear. Careful measurements have shown that hearing does not abruptly stop at 20Hz but the ear is capable of registering infrasound if the sound pressure is sufficient. Frequencies above 20Khz are considered ultrasound whilst frequencies below 20Hz are considered infrasound.

Low frequency sound has a relatively long wavelength and low material absorption rate, hence it has the ability to travel vast distances. These properties make it possible to achieve a profound effect on vast tracts of acoustic space with the production of high sound pressure level acoustic waves. Low frequency sound is non directional sound in it's propagation and therefore has the effect of enveloping the individual without any discernable localized source^[8].

Some animals such as elephants, hippopotamuses, rhinoceros and giraffes are known to use infrasound to communicate over distances. Many animals are able to perceive infrasonic waves that pass through the earth before natural disasters, which act as an early warning system for them.

Any severe and artificial extreme imposed on the sonic environment has a profoundly destabilizing effect on the individual, indeed infrasound has been used in the context of wars and nowadays there are currently several organizations conducting research in the area of acoustic weapons. However, natural low vibrations with an absence of high pressure can have a positive influence on human health and some people can perceive very low-frequency sounds as a sensation rather than a sound. Infrasound may also cause feelings of awe or fear in humans. Given it is not consciously perceived, it may make people feel that odd or supernatural events are taking place^[9]. So it is possible to hypothesis that where there are a lot of natural low vibrations present, ancient populations considered these sites to be "sacred".

The same argument could be applied to natural ultrasounds. The upper frequency limit in humans of approximately 20.000Hz is due to limitations of the middle ear, which acts as a low-pass filter. However, if ultrasound is fed directly into the human skull and reaches the cochlea through bone conduction, without passing through the middle ear, it is then possible to hear also these frequencies^[11]. Because in humans the upper limit pitch of hearing tends to decrease with age, children are able to hear some high frequencies sounds that older adults cannot^[10]. Ultrasounds are well known and used in the medical field. Ultrasonography is a diagnostic medical imaging

technique used to visualize many internal organs with real time tomographic images. Ultrasound is used for healing inflamed tissue and for therapeutic applications or in dentistry for cleaning tartar from teeth. Although the long term effects of exposure to ultrasound at strong intensity are still unknown, currently medicine considers the benefits to patients outweigh the risks. In contrast to medical applications ultrasound has been studied as a basis for sonic weapons, due to its direct effect on the human body and nervous system. Applications have been developed that include riot control through the disorientation of attackers and lethal levels of ultrasound that can be used like a gun. In fact high frequencies can readily be absorbed by materials and being highly directional they have incorporated in the design of acoustic weapons. It is probable that natural emissions of ultrasounds were heard by very young people of ancient civilizations as a supernatural sound, but in the rest of the population these were felt only as a good or bad sensation relative to the perceptible frequencies in a particular location along with the mystic aspect of the site.

From this assumption from 2010, we decided to begin researching these frequencies in "sacred" ancient and well known archeological sites. This study gave amazing results for a possible explanation as to why a particular site was considered sacred. We analyzed several ancient sites and we are focusing on other locations in Europe. In this paper we will speak about two such sites we analyzed: the Abbey of San Salvatore in Abbadia San Salvatore (Siena) in Italy for ultrasounds and Visocica Hill in Visoko Valley in Bosnia-Herzegovina for low frequencies and infrasounds.



Figure 1. The Abbey of San Salvatore in Abbadia San Salvatore (Siena)

III. MATERIALS AND METHODS

We used two types of dynamic high-end microphones extended in the ultrasound field together principally with a digital portable recorder with a maximum sampling rate of 192KHz (Tascam DR-680 of TEAC Group), but we controlled the result with other digital recorders (Tascam DR-100 and Marantz PMD661) with less technical characteristics.

For recording in water we used ultrasensitive omnidirectional microphones also used by sea biologists (Aquarian H2a-XLR Hydrophone, frequency response from

10Hz to 100Hz) with shielded water proof cable from factory, which we used especially for the tank of Abbey of San Salvatore. This type of microphone has a wide bandwidth typically used to hear the song of the whales up to several kilometers away. In this case the sound is transmitted very quickly in water, with the body of water acting as a reflector capable of capturing every vibration many meters away.

At the same time as recording in the air we used professional studio microphones with a wide dynamic range and a flat response at different frequencies (Sennheiser MKH 8020, response Frequency 10Hz - 60.000Hz) along with shielded cables (Mogami Gold Edition XLR) and gold-plated connectors.

Before recording we used a spectrum analyzer (Spectran NF-3010 from the German factory Aaronia AG) for searching electromagnetic phenomena present around us which could have had a negative influence on our results.

For analyzing audio records we used PRO TOOLS ver. 9.05 and Praat version 5.3.02 software for Mac to overlap and mix the various tracks recorded using two different methods of recording and Audacity ver.2.0.2 and Praat ver.5.3.35 for Windows.



Figure 2. The set used for recording in the Abbey of San Salvatore: the recorder Tascam DR-680 and Sennheiser MKH 8020 microphones

IV. THE ABBEY OF SAN SALVATORE

The first evidence of the existence of this monastic centre in this location dates back to a document from 762 AD, but the existence of this place can be traced back to the sixth century BC during the process of urbanization of Northern Etruria by the Etruscans.

The excavations carried out in the area of the abbey in the '90s however, also gave rise to the discovery of arrowheads and flint, indicating the presence of a population since the Upper Paleolithic period.

The abbey has a large sixteenth-century cloister with a huge tank of water, the depth of which is considerable and that according to oral tradition, sits on a natural source of water. It

also collects rain from the surface above and filters it with an ingenious system of cleansing by carbon tanks located on the sides.



Figure 3. The well at the centre of the cloister of the abbey of San Salvatore offers the only access to the huge tank below

The depth is greater than ten meters from the edge of the pit at the centre of the cloister. Such a tank of water is precious in archaeoacoustics because it works like a huge dish that collects the sound from underground, thereby behaving like a perfect transducer. Thanks to the availability of the monks still present in the abbey we proceeded to reopen the well at the center of the cloister which had been closed for over 15 years and introduced microphones in deep water.



Figure 4. two microphones Hydrophones being placed in the well, despite a cable length of 12 meters, they did not resting on the bottom of the tank



Figure 5. Immediately we observed a strong ultrasonic signal coming from underground

We also placed one other digital recorder in the cloister to verify the presence of spurious sounds from the environment that could affect the main recordings. But in all records we didn't find any anomalous noises from other sources.

We performed an immediate graphic control on the recordings so that optimal adjustments of the recording volume and execution times could be undertaken. We took ten recordings over a period of three hours with a long pause in between, but the same result was found in all recordings. We took these measurements at two different times of the year for three consecutive days.

The results appear extremely interesting: in all recordings made over two hours we found a very intense mechanical ultrasonic vibration present, oscillating between 26kHz and 30kHz with a mean peak around 28.000Hz. with the look of a Gaussian curve.

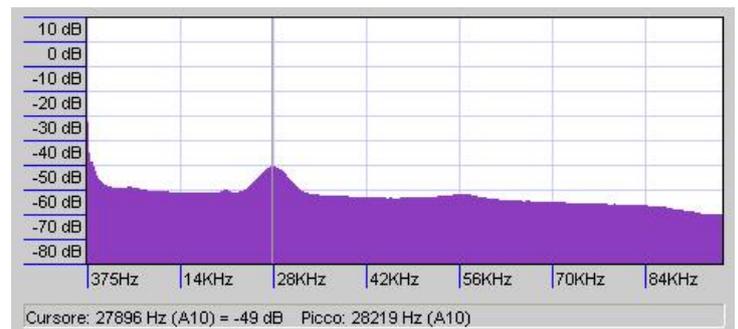


Figure 6. There is a peak of ultrasounds around 28.219Hz with an almost total silence on the other frequencies

Transposing the ultrasonic signal into the audible band was similar to a modulated whistle.

To check whether the signal was present in a larger area of the abbey we placed the microphones in a mining pond located less than 500 meters away, we also examined other bodies of water nearby and in neighbouring locations, but we did not find any ultrasonic frequencies present as those found in the Abbey of San Salvatore.

V. VIŠOČICA HILL

The hill of Višočica is in Bosnia and Herzegovina and on the top can be found the site of the Old town of Visoki. Visoki was a famous medieval royal castle town and monastery destroyed by the Ottomans during the fourteenth century. The first mention of the town was in 1355 by King Tvrtko I of Bosnia, but from ancient artifacts found in that location we can suppose that a settlement was present from very ancient times.

During 2010 together with archaeological researches by Bosnian Pyramid of the Sun Foundation in Visoko Valley, Dr. Slobodan Mizdrak discovered an interesting natural emission of radio waves on the top of the hill among the ruins of the Old Town. These emissions were confirmed with an experiment in April 2011 (7), so our research group began to study the archaeoacoustics aspects of this site from 2011.

Also in this place we found ultrasounds of a frequency around 28,4KHz, but not constant (12). So we decided to analyze the site using the same methods as those used on the Abbey of San Salvatore.

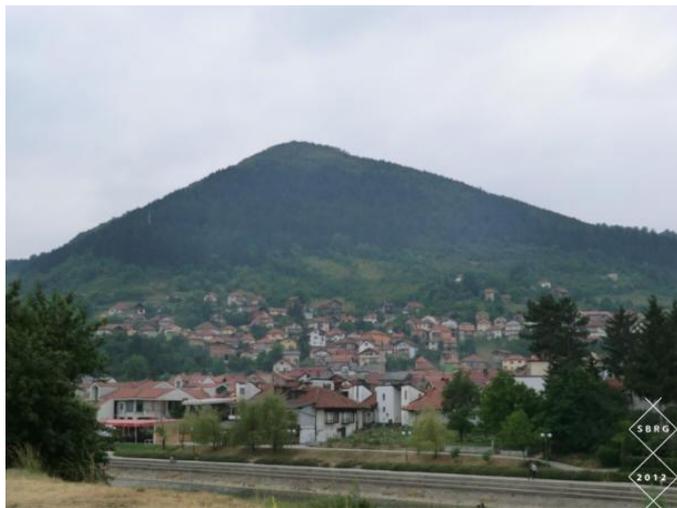


Figure 7. Višočica Hill also called Bosnian Pyramid of the Sun for its pyramid shaped aspect is over the new town of Visoko (Bosnia-Herzegovina)

We found a very strong emission of low frequencies and infrasounds around the top of the hill. The range in total silence and with an absence of wind was between 10 Hz and 70 Hz with a large peak around 48 Hz. The volume was not elevated. This mechanic vibration is the most likely reason why so many sensitive people have the sensation of energy when they arrive on top of Višočica Hill visiting the ruins of an ancient castle. Below a particular volume we perceive low sounds better by vibration through sensors in human bones than by ear. This volume cannot create damage to human health, but we cannot be sure what happens over a long period of exposure.



Figure 8. The ruins of the ancient Old Town of Visoki. The position of the microphones are pointed out by red circle.

We searched for the same vibration on the hills around in the surrounding valley but we didn't find any similar. We tested these results for two years using different equipment.

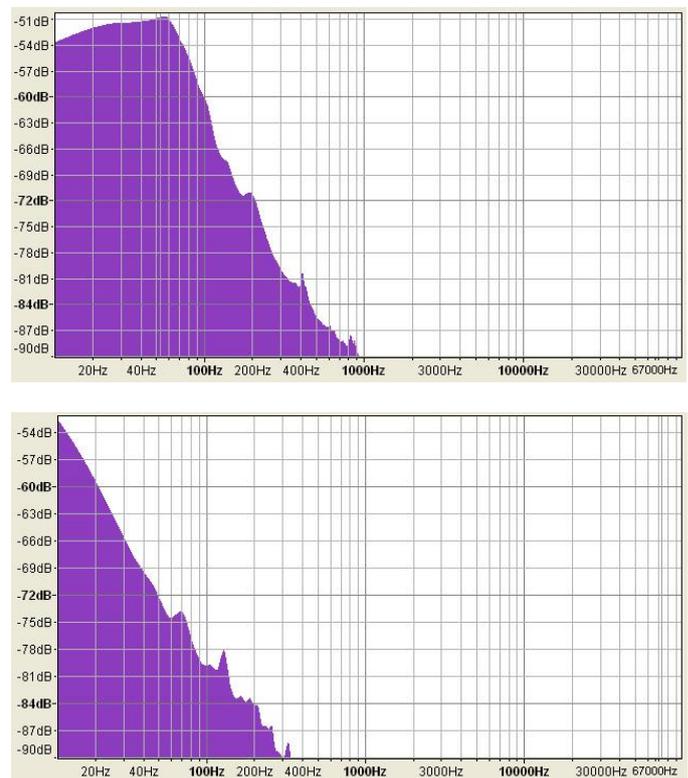


Figure 9. Top: the graphic aspect of sound recorded on Višočica Hill. Below: graphic aspect on a hill in a neighbouring location, the difference in frequencies between 10 and 70 Hz and the peak around 48 Hz is evident.

VI. CONCLUSIONS

The thesis, that our research group (SBRG*) has followed for more than three years, is that natural phenomena in the band of audible sound, infrasonic or ultrasonic, and electromagnetic or geodynamic phenomena may have had a

close connection with aspects of spirituality of particular places. These characteristics appear to have ultimately influenced the choice of construction of a particular temple in a certain location. We observed that when we found a natural interesting phenomenon, the archaeological site was very ancient and important and had a church or temple present long before the arrival of medieval churches. We also collected not significant data from chapels and medieval sites which appeared very interesting for their mystical nature and religious importance, but without any physical/mechanical secrets. In our archaeoacoustics research we also found some sites with interesting phenomena in suggestive archaeological locations without finding any significant archaeoacoustics features.

The Abbey of San Salvatore sits at the foot of Mount Amiata in Tuscany built over an ancient sacred Etruscan settlement. Mount Amiata is an extinct volcano, but some activity remains underground. It is likely that these natural sounds, perceptible even to a sensitive ear to the ground, were also present at the time of the Etruscans who were greatly impressed by them as the voice of God and therefore lead them to consider these locations sacred. Because ultrasounds are very directional our protocol proposes to use all possible stagnant bodies of water as a parabola for receiving sounds by Hydrophones and the huge tank of water of the abbey was perfect for this use. But no infrasounds or low frequencies were found here.

On the contrary the low frequencies and infrasounds found on Visočica Hill explain very clearly the sensation of mysticism which some people perceive in this place and how is very easy for those practising meditation can apply this technique at this site. We can suppose that these frequencies are probably coming from a nearby earth fault and are concentrated by the pyramid shape of Visočica Hill. In fact there are no similar frequencies in the surrounding hills. There is an ongoing debate that the Old Town on the top had or was also a monastery, but all historians agree it was the location where many important historic documents of medieval Bosnia were written and signed. So it was a place where wisdom, culture and attention was common, helped by this good natural environment. Because infrasounds and low frequencies are not directional, for our protocol we needed to capture these sounds using professional microphones with a flat response on all frequencies and a deep response in all frequencies. In either case, researching ultrasounds or low frequencies, it is very important to use well shielded cables with gold-plated connectors to avoid picking up radio waves from other sources.

Living our modern lives in urban towns and cities, we are dipped in a lot of bad mechanic vibrations with a high volume which in most cases is very detrimental for health. In contrast, in their absence ancient people would have been more attuned to natural vibrations. They understood the best locations to go to so they could make contact with God through their prayers, leading them to build their temples in these locations.

In conclusion as our experience demonstrates, archaeoacoustics appears to be an interesting new method for reanalyzing ancient sites using different study parameters. This reaffirms the aura of legends that pervades these places, and modern technology is now able to give greater clarity to the origin of many interesting phenomena.

ACKNOWLEDGMENT

We are grateful to Department of Medical Sciences of the University of Trieste (Italy) for supporting in our research and in particular to the Director, professor Roberto Di Lenarda.

Sincere thanks for helping our archaeoacoustics research to the monks of San Salvatore and in particular to the prior Father Amedeo and Father Roberto, who always patiently tolerated our invasions. Thanks for collaboration in our archaeoacoustics research to of the Bosnian Pyramid of the Sun Foundation too.

REFERENCES

- [1] P. Debertolis, H.A. Savolainen, "The phenomenon of resonance in the Labyrinth of Ravne (Bosnia-Herzegovina). Results of testing" ARSA Conference (Advanced Research in Scientific Areas), Bratislava, December, 3. - 7. 2012
- [2] R.G. Jahn, et al.: "Acoustical Resonances of Assorted Ancient Structures," Technical Report no.95002 PEAR, Princeton University, March 1995.
- [3] R.G. Jahn, P. Devereux, M. Ibson: "Acoustical Resonances of Assorted Ancient Structures," J. Acoust. Am Soc Vol.99 No.2, February 1996 pp.649-658.
- [4] P. Devereux, et al: "Acoustical Properties of Ancient Ceremonial Sites," Journal of Scientific Exploration, 9: 1995, pp.438.
- [5] W. R. Corliss, G. Arm: "Ancient Structure. Remarkable Pyramids, Forts, Towers, Stone Chambers, Cities, Complexes. A Catalog of Archeological Anomalies ", The Sourcebook Project, 2001, Hardback, Maryland
- [6] C. Garza, A. Medina, P. Padilla, A. Ramos, F. Zalaquett: "Arqueoacústica maya. La necesidad del estudio sistemático de efectos acústicos en sitios arqueológicos", Estud. cult. maya vol.32, 2008, México, (ISSN 0185-2574)
- [7] S. Mizdrak, "The results of April experiments with EM and US transceivers" presentation at Hidden History Conference, Visoko, September 8, 2012, SB Research Group page on YouTube, <http://www.youtube.com/watch?v=IEXoHp36JR0&feature=g-all-u>
- [8] V. Gavreau, "Infrasound : Subjective Effects", Science: Vol 4, No.1 - January 1968
- [9] V. Tandy, T. Lawrence, "The ghost in the machine" *Journal of the Society for Psychical Research*, April 1998, 62 (851): 360-364
- [10] S. Takeda, I. Morioka, K. Miyashita, A. Okumura, Y. Yoshida, K. Matsumoto, "Age variation in the upper limit of hearing", *European Journal of Applied Physiology*, 1992, 65 (5): 403-408
- [11] J. F. Corso, "Bone-conduction thresholds for sonic and ultrasonic frequencies". *Journal of the Acoustical Society of America*, 1963, 35 (11): 1738-1743
- [12] P. Debertolis, "Measured Energy Phenomena", presentation at Hidden History Conference, Visoko, September 8, 2012, SB Research Group page on YouTube, <http://www.youtube.com/watch?v=fswpj2dHAo>

* Note. SB Research Group is an international and interdisciplinary project team of research (Italian, Croatian and Finish members) on archaeo-acoustic of ancient sites and temple in Europe (Official web site: <http://www.sbresearchgoup.eu>).