

Archaeoacoustics in ancient civilizations

How to approach this new complementary discipline to archaeology

prof.agg. **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

Nina Earl, BSc

Scientific assistant
Project SB Research Group*
London – United Kingdom

Abstract — Archaeoacoustics is a relatively new approach to analyze any archaeological sites that has interesting acoustic characteristics. It can be used to demonstrate sound occurrences believed to have been incorporated into the design by the architects of certain structures. Another aspect of archaeoacoustic research can understand how such structures affect brain activity, useful during rites where an altered state of mind intensifies the experience. Natural phenomena can also influence the psychological state for example by inducing mystical states. We have demonstrated ancient civilizations had some knowledge of this phenomena, through understanding the significance specific locations were chosen for buildings such as temples. Using digital recording equipment, it is now possible to record non-audible sound frequency bands. These bands have a direct effect on the human body and mind without a person being aware of the existence of their accompanying mechanical vibrations. The hypothesis of SB research group is that at some archaeological sites, exists a measurable natural audio or electromagnetic phenomena that enhance its mystical properties. Following this line of research, interesting archaeoacoustic effects have been discovered at a number of sacred sites from Malta to Turkey and Serbia to Italy. Incorporating a neurophysiological approach, is adding weight to this hypothesis.

Keywords: *archaeoacoustics, ultrasounds; infrasounds; low sound frequency.*

I. ARCHAEOACOUSTICS

Archaeoacoustics is a complementary approach to archaeology, it is a new perspective to analyze archaeological sites which sometimes have interesting sound characteristics [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16]. It can demonstrate sound occurrences planned by the builders of some structures. Natural sound phenomena were used in several civilizations to create impressive rites, with some ancient structures designed in a such a way as to directly influence the mind through the vibrations they produced towards a particular state of consciousness [7,16,17,18]. This point of view of ancient sites has had more expansion in the nineties and our research group has followed this road since 2010 investigating a large group

of “sacred” sites in Europe and Asia (England, Bosnia, Serbia, Slovenia, Italy, Portugal, Malta and Turkey) publishing our conclusion. Using modern digital recording techniques it is now possible to record very clearly non audible sound frequency bands such as ultrasound or infrasound, which are able to modify the brain activity. It is also possible to make visible and display magnetic fields affecting the mind; using UV Imaging, photography and special software to show the micro-movement of air crossed by magnetic forces^[8,13,16]. We discovered that the most part of really sites from Gobekli Tepe in Turkey to Tarxien Temples in Malta, from Alatri Acropolis in Italy to Felix Romuliana Palace in Serbia are all placed over sources of natural low frequencies or magnetic fields which affect human brain activity. We also reproduced the band of vibrations found by other authors in some sacred sites in UK and Ireland in the laboratory and in one sacred site in Italy, confirming that these vibration interfere with human mind in various ways^[7,16]. Sometime these bands of sounds have a direct effect on the human body without a person being aware of the associated mechanical vibrations. So after the analysis of about thirty ancient sites the hypothesis of our research group was confirmed and became a thesis. This is: in some archaeological sites considered sacred for thousands of years, there are measurable natural audio phenomena (or magnetic field) that make the place somewhat more mystical than others. How between 11.600 and 2,000 years ago the builders of the temples were able to find the right location for their temples without the use of the measuring devices we have today? We cannot know this for the most ancient civilizations without a written source, but we know that ancient Romans had this knowledge because we have historical records speaking about this. These techniques were used to find the optimal location for military camps, public buildings or spas, being careful to avoid any potential negative impact on health^[15]. It is believed that the empirical knowledge handed down to the Romans from the Etruscans, resulted in the Romans holding their soothsayers and in particular a category of priests, called the augurs in high esteem^[12].

II. INFRASOUNDS, AUDIBLE LOW FREQUENCIES, ULTRASOUNDS AND MAGNETIC FIELDS

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. Frequencies above 20Khz are considered ultrasound whilst frequencies below 20Hz are considered infrasound. 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.

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.

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^[2]. So it is possible to hypothesize that where there are a lot of natural low vibrations present, ancient populations considered these sites to be "sacred".



Fig. 1 – A subwoofer emitting 18Hz at low volume was positioned close to an incubator where some human cardiac cells were growing. After few minutes all the cells were died. This can express that some “not lethal” weapons are not devoid of serious effects to human body.

In our experience in laboratory research we are conducting on human cardiac cells in collaboration with University of Udine (Italy) we have been able to kill these cells in few minutes after an exposure to 18Hz (Fig. 1). We realized that the vibrations destroyed the cytoskeleton of human cells by interfering with their quantum vibration. This research is currently ongoing, but it shows how some low vibrations can be dangerous for human health and also used as a weapon.

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 also hear these frequencies^[2]. 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. 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 the medical profession 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 as they are highly directional they have been 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.

For a long time neurology has been studying brain magnetic activity deriving from electro-activity of the brain with good success. For example the MEG (magnetoencephalography) allow the recording of cerebral electromagnetic activities with excellent temporal resolution. These tools have also considerably progressed in spatial resolution and now constitute real methods of Electric and Magnetic Source Imaging (a). Nowadays this method contributes to the presurgical evaluation of pharmacoresistant partial epilepsies^[19].

In recent years the electromagnetic theories of consciousness propose that consciousness can be understood as an electromagnetic phenomenon. Electromagnetic field theories (or "EM field theories") of consciousness propose that consciousness results when a brain produces an electromagnetic field with specific characteristics. Neurophysiological observations made by Freeman over several decades contribute to the idea that brains are essentially non-equilibrium systems which do not come to a steady state even for a fraction of second. Brains constantly change, using

dynamical patterns of activation in their operation to present memories, concepts, and actions. These considerations suggest that the brain's integrative functions are the result of competition of complementary tendencies of cooperative integration and autonomous fragmentation among many distributed areas. The interplay of these two tendencies (autonomy and integration) constitutes the metastable regime of brain functioning, whereas local (autonomous) and global (integrated) processes coexist as a complementary pair, not as conflicting principles^[20].

A natural magnetic field can affect brain activity in the same way. This is not the place to discuss problems associated with artificial magnetic fields emitted by modern technology, but research carried out at different sites using modern technology, has confirmed that various locations have a strong natural magnetic field which directly affects brain activity. Ancient populations were more sensitive than our civilization, and by using empirical methods they realized that some sites had somehow changing their consciousness and creating an altered state of mind^[16,21].

III. HOW TO MOVE INTO ARCHAEOACOUSTICS?

For recording **sounds** we use 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.

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.



Fig. 2 – The set-up used for recording sounds: the recorder Tascam DR-680 and Sennheiser MKH 8020 microphones in Enclosure D of Göbekli Tepe ancient site (South-East Anatolia).

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. This type of microphone has a wide bandwidth typically used to hear whale song 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.



Fig. 3 – The Aquarian H2a-XLR Hydrophone.



Fig. 4 – Two microphones Hydrophones were placed in the main well of the Medieval Abbey of San Salvatore which is at the foot of Mount Amiata in Tuscany (Italy). Mount Amiata is an extinct volcano, but some activity remains underground; at the time of the Etruscans who were greatly impressed by the vibrations, considering it as the voice of God and therefore led them to consider these locations sacred.

For recording ultrasounds we use a Pettersson D1000X Bat detector and Bat sound software, Pettersson Elektronik, Uppsala University. It is the best source for recording ultrasounds from every source. Originally built for recording ultrasounds from bats, this device is very useful for recording natural ultrasounds up to 400.000Hz.



Fig. 5 – The Pettersson D1000X Bat detector from Swedish firm Pettersson Elektronik.

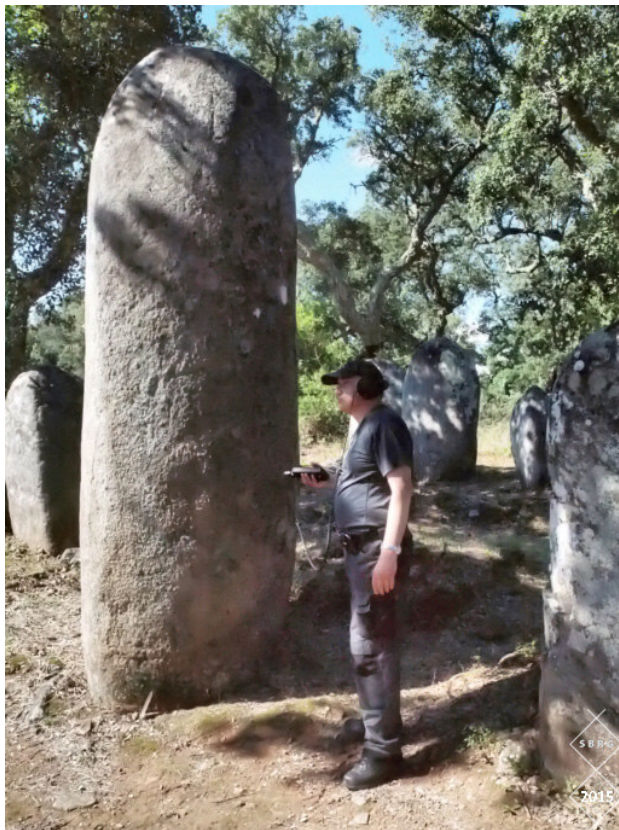


Fig. 6 – The Pettersson D1000X device was used for detecting the emission of ultrasounds from the granite of the megaliths in Portela de Mogos (Portugal) when hit by the sun. It is also possible that in ancient times the population living without the presence of noise pollution of modern civilization could possibly have felt this vibration; without the distraction from various machine tools or transportation, without the noise of loud music and living in perfect harmony and connection with nature.

Before recording we use 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.



Fig. 7 - Spectran NF-3010 from the German factory Aaronia AG.

Praat program version 4.2.1 from the University of Toronto and Audacity open-source program version 2.0.2, both for Windows were used to analyze the various recorded tracks.

We also use a geologic device for confirming what we find by microphones in infrasound range. It is GeoBox SR04S3 Datasheet from Italian firm SARA. The digital sensor SR04 GeoBox is a high-performance instrument especially suitable for acquiring signals for seismological and geophysical surveys such as the Horizontal/Vertical Spectral Ratio - HVSr. The SR04 GeoBox is designed especially for recording ambient seismic noise, but it can also record earthquakes and artificial vibrations. Compact, reliable and simple, it is fully functional within minutes after deployment.



Fig. 8 – Left: GeoBox SR04S3. Right: the device connected with the computer at work.

To make visible the shape of the **magnetic field**, UV photography and a vector program for PC (PIV – Particle Image Velocimetry) was used. This consisted of a modified Canon EOS 1100D digital camera, with its anti-aliasing filter removed. The camera used was modified in Canon's Italian factory (1). In the ultraviolet band (UV) the absorption of lenses of normal optics (lenses without calcium fluoride and quartz for forensic use) is very strong, usually a normal optic is unable to allow electromagnetic waves below 320-350nm to pass through, but it is sufficient for analyzing the UVA band (400-315nm) where it is possible to perceive the movement

¹ Any new camera can be modified in this way, however Nikon, Sony and Olympus cameras can only be modified by a private technician automatically invalidating the warranty of the firm, and the camera can lose characteristics necessary for scientific use.

and the behaviour of dust suspended in the air, and gas flows as a water steam which orientate itself as a dipole in the magnetic field [14].

Particle Image Velocimetry (PIV) by Dantec Dynamics from Denmark is the software used to analyze this movement in the UV video and photographs taken. PIV is used in industry as an intuitive measurement technique to measure two or three components of velocity in a variety of flows. The application of PIV in research and industry is widespread, due to its ease of use and accurate data representation. As easy and intuitive as PIV is, it involves many cross-disciplinary challenges, from classical optics and imaging to the use of dedicated state-of-the-art digital electronics and lasers. The principle of PIV working is very simple: two consecutive shots illuminate a slice or volume of a flow field with particles suspended in the flow. The scattered light from the particles is recorded in two consecutive images on one or several digital cameras. The images are sub-divided into smaller areas for calculating the mean particle displacement between two corresponding sub-areas. The particle displacement is calculated using cross-correlation or Least Squares Matching techniques. Since the time between the shots is known, the particle velocity can be determined. Taking into account the magnification of the optical setup, the absolute velocity field can be derived. The velocities calculated from an image pair are an instantaneous snapshot of the flow viewed by the cameras. PIV results are an accurate representation of the flow presented to the user and viewers in an easy to understand and visual manner. The presentation is aided by advanced soft-ware post-processing. Dantec Dynamics is the leading provider of laser optical measurement systems and sensors for fluid flow characterization and materials testing.

IV. RESULTS OF OUR METHODS

It's not possible to summarize all the results found during from six years of research. However, the thesis SB research group (SBRG*) proposes is that natural phenomena in the audible, infrasonic or ultrasonic sound bands, and electromagnetic or geodynamic phenomena may be closely connected to particular aspects of spirituality. These characteristics appear to have ultimately influenced the choice of construction of a particular temple in a certain location. It was observed that when a natural phenomenon was found, the archaeological site was ancient and important and had a church or temple present long before the arrival of medieval churches. Non significant data was also collected from chapels and medieval sites of religious importance, that also appeared to offer mystical properties, but without any such physical or mechanical. On the contrary, many locations built between the Neolithic Age to the Fall of Roman Empire have some interesting phenomena suggested by the archaeology without their being any significant archaeoacoustical features. Was this knowledge perhaps lost in the Middle Ages?

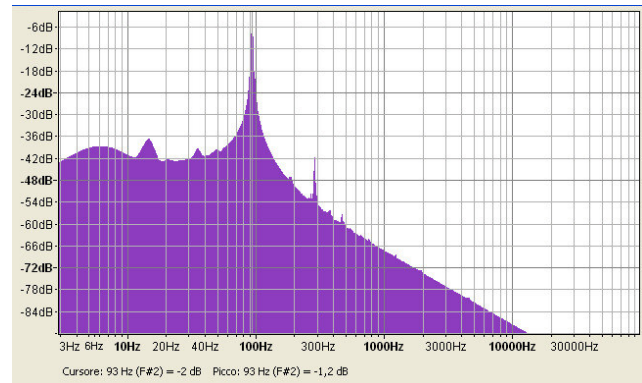


Fig. 9 – The typical aspect of resonance found in a niche of a subterranean shrine located in Sogmatar (Turkey). The temple was built with this purpose because the peak is located in the range 70-130Hz of a male voice and affecting brain activity.

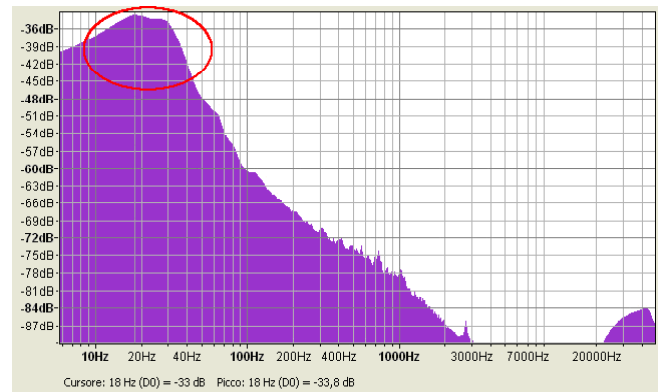


Fig. 10 – Graph of the recordings made in the Temple of Cybele (III century AD) located in the imperial Roman palace Felix Romuliana in Serbia. There is a strong peak of low frequencies and infrasounds inside the "fossa sanguinis" of the temple. These low frequencies and infrasounds would certainly have contributed to a general atmosphere of excitement and/or fear in those participating in any rituals inside this temple.

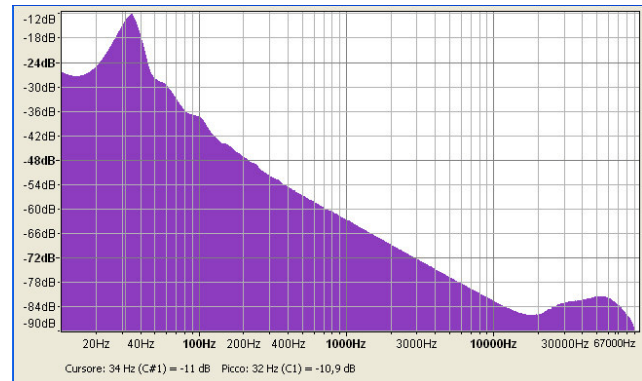


Fig. 11- The peak of frequency found in the Neolithic Xaghra Circle in the island of Gozo (Malta). In this case the peak is at 34Hz.

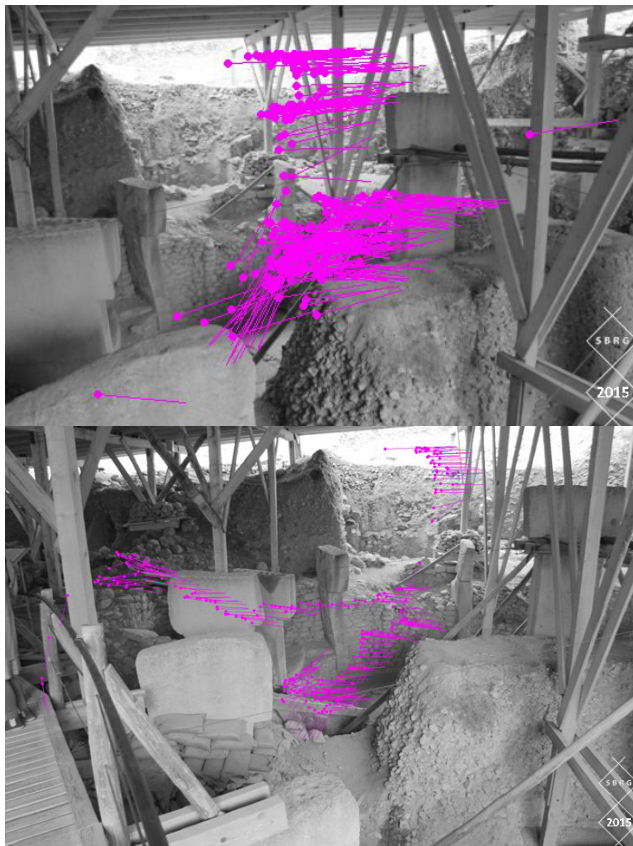


Fig. 12 – The aspect of a magnetic field found in Enclosure D of Göbekli Tepe ancient site (South-East Anatolia). The image is taken by UV camera and elaborated by PIV software.

V. CONCLUSIONS

The low frequencies, infrasounds, ultrasounds, magnetic field found in several ancient sacred sites explain very clearly the sensation of mysticism which some people perceive in these places and how it is very easy for those practising meditation at these sites to apply their techniques. We can suppose that these frequencies are probably coming from geological faults or from the movement of underground water. These sacred sites were 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 exposed to 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.

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- * Note. Super Brain Research Group (SBRG) 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>).