

The ancient knowledge of sound. Archaeoacoustic analysis of the Pyramid of Bomarzo and the surrounding areas in Lazio, Italy

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Abstract – The term "archaeoacoustics" does not simply mean the study of sound in archaeological contexts, but also the study of all physical phenomena in these sites. Using an archaeoacoustic approach it is possible to measure the frequencies of natural sounds and magnetic fields of archaeological sites and to interpret their possible sacred function. In previous research our research group (SBRG - Super Brain Research Group), an interdisciplinary team of researchers from various European countries, has demonstrated in some ancient temples the existence of a relationship between mechanical vibrations or magnetic fields induced by natural phenomena and brain activity. For the pyramid of Bomarzo, an ancient archaeological site in Lazio (Italy), we applied the same standard of research that we have used for several years. It is without doubt that the Bomarzo pyramid area owns typical characteristics of similar sacred sites we have previously examined in other locations. The presence of 14Hz almost everywhere at different volumes in the Bomarzo pyramid area is a feature we have often met with at other sacred sites such as Sogmatar and in Göbekli Tepe in South Anatolia where it was also possible to localize a similar powerful magnetic field as in the Bomarzo pyramid.

Keywords – sound, archaeoacoustics, Bomarzo, pyramid

1. Introduction

During the nine months of gestation a fetus perceives the beating of the maternal heart. This sound is the first thing that human beings perceive even before seeing light. So a constant rhythmic sound will always be part of a human's genetic heritage. It is the beating that marks the presence of life. For the first hominids living on Earth this heritage helped ensure their survival. Everything they smelled, saw and in particular the sounds they heard were certainly perceived and assimilated in the same way as the animals with which they shared the external space. Living in symbiosis with nature, free from any form of pollution, they instinctively perceived inaudible vibrations very clearly. Listening to the silence they learned to refine their senses and realized there was a relationship between vibrations coming from a particular location and their effects on the human body. In the same way, but using an empirical approach, they recognized strong natural magnetic fields able to heavily influence brain activity. Considering these two observations the choice of their sacred places would not have been by chance. The term "archaeoacoustics" does not simply mean the study of sound in archaeological contexts, but also the study of all physical phenomena in these sites. Using an archaeoacoustic approach it is possible to measure the frequencies of natural sounds and magnetic fields of archaeological sites and to interpret their possible sacred function. Archaeoacoustics can also help explain why some ancient structures were built or carved in certain locations. Firstly because natural sound phenomena have been used to create suggestive rituals in many civilizations, and secondly it is also known that some ancient structures have been specially modeled to directly affect the mind producing an altered state of conscience [1,21]. In previous

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research our research group (SBRG - Super Brain Research Group), an interdisciplinary team of researchers from various European countries, has demonstrated in some ancient temples the existence of a relationship between mechanical vibrations or magnetic fields induced by natural phenomena and brain activity [2 – 20, 23]. Using modern technology, able to recognize vibrations and magnetic fields, and after studying about forty ancient sites from 2010 to 2017 in Europe and Asia Minor, we can say there are natural phenomena in some archaeological sites, considered sacred for thousands of years, which make these sites more mystical than others. So for the Pyramid of Bomarzo, an ancient archaeological site in Lazio region (Italy), we applied the same standard of research that we have used for several years [2 - 20, 23]. It is without doubt that the Bomarzo Pyramid area owns typical characteristics of similar sacred sites we have previously examined in other locations. The presence of 14Hz almost everywhere at different volumes in the Bomarzo pyramid area is a feature we have often met with at other sacred sites. Thanks to new technologies we were also able to draw the shape of a powerful magnetic field which is present in and over the pyramid. Only in the sacred sites of Sogmatar [14] and in Göbekli Tepe [20] in South Anatolia was it also possible to localize similar powerful magnetic fields just as in the Bomarzo pyramid.



Figure 1 – A drawing of the Bomarzo Pyramid by N. Tarabella, which shows its unique structure carved from a singular block of stone.

2. The Bomarzo Pyramid

The Tacchiolo valley (Viterbo, Italy) is full of ancient stone artifacts and structures including the so-called Pyramid of Bomarzo (Fig.1), a carefully sculpted large natural magmatic rock. This enigmatic structure obtained from a single block of rock of volcanic origin and about 16 meters high, whose origin probably dates back to the Rinaldonian period, owes its name to the lateral pyramidal shape. In fact, the Rinaldonian Civilization, preceding Etruscan Civilization, had great skills in working with stone and built their homes and tombs in the rock and always placed them near water sources. Frontally the structure looks like a large altar, with a series of steps that climb up to the top, and spaces carved into the stone. On the left side of the pyramid, a long and narrow staircase is carved that reaches the first altar. On the right side, there is a second altar flanked by a ladder that goes up to the top. Between the two areas, a series of larger steps have been excavated leading to the "high place" of the structure. We can hypothesize that that the location had a religious purpose connected to the use of water. This is supported by the presence of a quadrangular stone basin, overlooking the pyramid, used for sacred ablutions. Also on the pyramid a long narrow channel was dug, which was probably used for the drainage of liquids used during the rites. The

sacrificial nature of these rites is not ascertained, but the fact that the sun disappears behind the pyramid at noon, leaving it completely in the shade, is certainly not accidental. Over the centuries, this mystical structure has survived the passage of religious syncretism, as witnessed by the Christian crosses engraved on the pyramid but has always preserved its original sacred function and, still today, is surrounded by an aura of mystery. We also examined from an archaeoacoustic point of view the rock anthropic structure in the neighborhood as the so called “Finestraccia (bad windows)”, a rock temple or a house which has on the upper external level a large thick circle carved in the rock also aligned to the equinox (Fig. 2, left). Inside this rock temple we found an interesting resonance frequency (fig. 2, right) by using our voice and a sciamanic (or Irish) drum.



Figure 2 – On the left: the large circle carved in the rock aligned to the equinoxes placed in the upper level of the Finestraccia. **On the right:** the test for researching the resonance phenomenon inside the rock temple using a sciamanic or Irish drum.

3. Materials and methods

The audio recording was performed following the SBRG Standard for Archaeoacoustics (SBSA) we used for a long time (2-20). In this case the equipment consisted of a high range dynamic recorder, extended in the ultrasound and infrasound field with a sampling frequency rate of 192 kHz (Tascam DR-680 by Japanese TEAC Corporation), and two professional condenser microphones with a wide dynamic range and flat response at different frequencies (Sennheiser MKH 3020, frequency response between 10Hz and 50,000Hz) with shielded cables (XLR Mogami Gold Edition) and gold plated connectors. We placed the microphones at the base, in contact with the soil, and on the top of the pyramid. Sometimes, for avoiding magnetic interference we noticed after the first recordings, we inserted the microphones directly in the body of the recorder.



Figure 3 – The digital recorder Tascam DR-680 placed inside the structure carved in the rock behind the pyramid with the microphones inserted in the body of the device.

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 analyse the audio recordings.

Before recording a spectrum analyzer, Spectran NF-3010 from the German factory Aaronia AG), was used to detect the presence of any electromagnetic phenomena which could influence the results.

To make the shape of the magnetic field visible, UV photography and a vector program for PC (PIV – Particle Image Velocimetry) was used. This consisted of a modified Canon EOS 1100D digital camera [14,15,16,17,19], with its anti-aliasing filter removed. The camera used was modified in Canon's Italian factory ⁵. In the ultraviolet band (UV) the absorption of lenses of normal optics (not with calcium fluoride and quartz lenses 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 analysing the UVA band (400-315nm) where it is possible to perceive the movement and the behaviour of dust suspended in the air and the flow of gas as steam which orientates itself as a dipole in the magnetic field. Particle Image Velocimetry (PIV) by Dantec Dynamics from Denmark was the software used to analyze this movement in the UV video and photographs taken (Fig. 4). 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 it being easy to use and its 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 material testing.

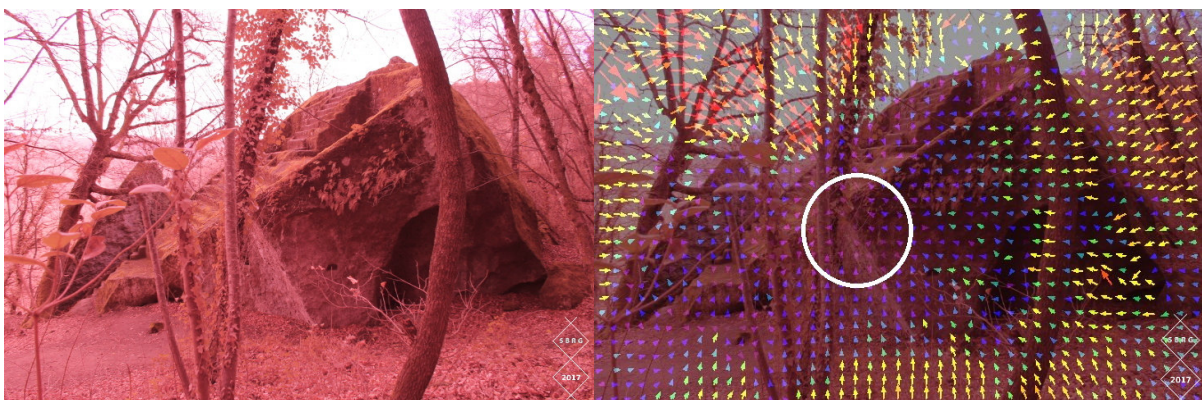


Figure 4 – On the left: image in UV band and visible as in person. **On the right:** the same frame of the video treated with the PIV program which shows a spiral magnetic field directed towards the center of the Bomarzo pyramid.

5 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 loose characteristics for scientific use.

For our local radioactivity measurements we also used a Geiger counter GAMMA-SCOUT model w / ALERT of German construction, with the detector tube type Goigor-Mullor, steel coating filled with halogen gas and possibility to dose the alpha, beta and gamma rays by rotating-ray discriminator.

4. Results

4.1 Bomarzo Pyramid

The graphs below, which represent the sound analysis of the recordings taken on the 'Pyramid of Bomarzo', show infrasounds at the base of the pyramid whose main dominant is represented by 14Hz at medium volume (Fig. 5). This sound probably derived from the movement of groundwater, also at the level of the cups carved in the rock and placed above the Finestraccia (Fig. 6). At the top of the pyramid the sound changes and extends itself with a wider peak, from 7-8Hz to 14Hz already detected at the base (Fig. 8). It is probable that this difference is due to the interference of the 'pyramid'. The pyramid looks to change the character of the sound thanks to its shape which modifies the transmission of the sounds coming from the subsoil. But if you listen to the sound transposed in an audible band, in order to make audible infrasounds normally not perceivable by the human ear, it seems to be manipulating more than just the sound due to the magnetic field, which is confirmed by the existence of the UV band imaging technique with the use of the PIV software.

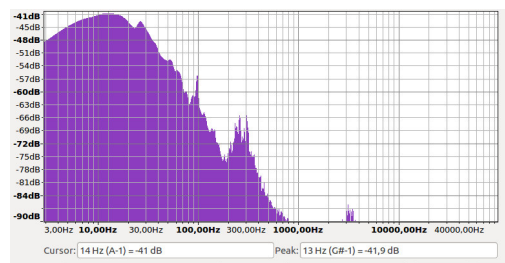


Figure 5 – Graph of infrasounds at the base of the pyramid with microphones placed in the air. There is a peak with apex around 14Hz at -45db.

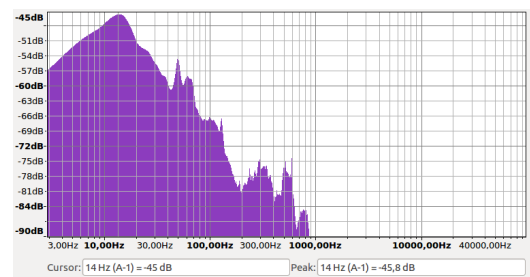


Figure 6 – Graph of the infrasounds found at the level of the cups carved above the Finestraccia. There is a large peak with an apex at 14Hz and a higher volume (-41db) compared to the base of the pyramid.

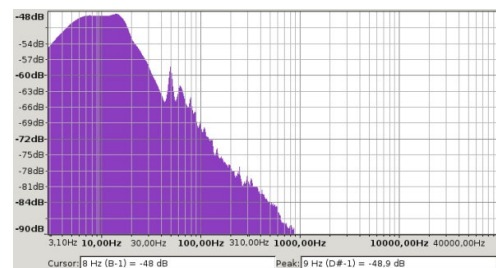


Figure 8 – Graph of infrasounds found at the apex of the Pyramid of Bomarzo: the sound changes character extending the peak with a wider plateau starting from 7-8Hz up to 14Hz already detected at the base of the pyramid.

Using ultraviolet band imaging techniques and vectorial software, capable of unveiling possible magnetic fields, we have highlighted the presence of a spiraling magnetic field, which seems to attract particles towards the depth (Figure 9, left). That is, the magnetic field detected appears to be directed towards the subsoil and not upwards, as often happens. It is therefore possible that the pyramid acts with its morphology, like a vector pointing towards the subsoil. This magnetic field, due to its power and amplitude, has a certain effect on the human body and is also present at the apex of the pyramid itself (Figure 9, right).

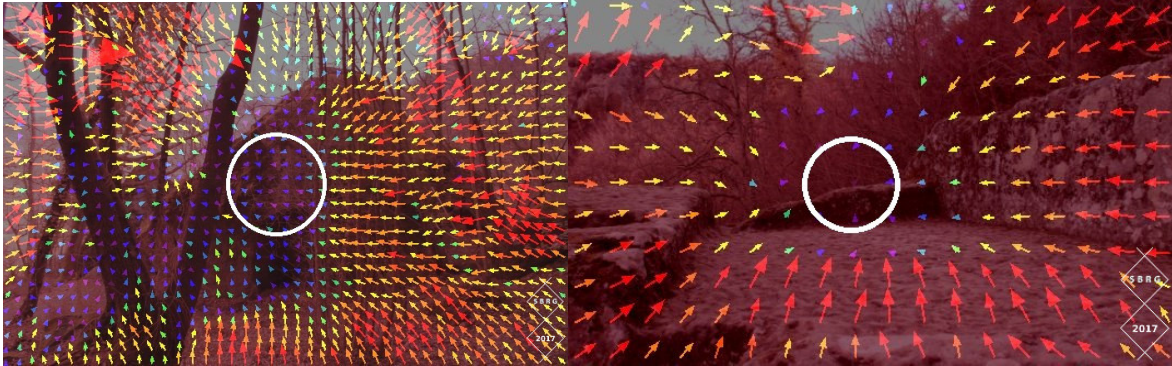


Figure 9 – On the left: from the direction of the vectors it is possible to identify a very powerful magnetic field that is centered on the pyramid. On the right: the magnetic field appears also at the center of the apex of the pyramid.

4.2 Finestraccia

In addition to the previous comparative archaeoacoustic analysis of the cups placed above the so-called 'Finestraccia', we also wanted to examine the rock structure in itself. We therefore tried to detect the presence of infrasounds, but we also realized that we could stimulate the resonance present in the room, both with a male voice and with a shamanic drum. This structure, whose entrance is oriented perfectly to the east, apparently presents two levels, even if the attic that divided it into two rooms is now no longer present. However we cannot know whether the construction of such a floor, and therefore the separation into a superior and a lower room, was only the result of a residential renovation of what we suppose to be a temple. Upon entering there is a sort of sepulcher carved into the rock, to the right of the entrance, similarly though you cannot know whether it is contemporary or subsequent to the excavation of the structure.

The shamanic drum stimulates the resonance at about 97-98Hz, as can be seen from the graph below (Fig. 10). In it the highest peak is not the base frequency of the drum, already known and measured in the laboratory and located around 58Hz, but the response of the room. In fact, this responds by releasing sound energy thanks to a superior harmonic of the drum. This sound energy is added to the upper harmonic of the drum, thus generating a higher peak. Usually, the harmonics above the base sound all have a lower volume than the dominant note of the drum, so it is easy to recognize the resonance frequency of the room.

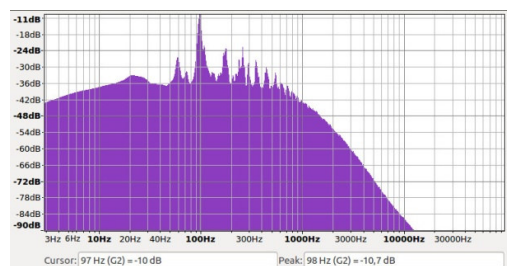


Figure 10 – The resonance peak response determined by the shamanic drum around 97-98Hz is clearly evident.

This data is also confirmed by the use of the male voice, which can stimulate the room in the same way and produces a frequency very close to the previous one, focused around 95-96Hz, as can be seen in the graph in Fig. 11.

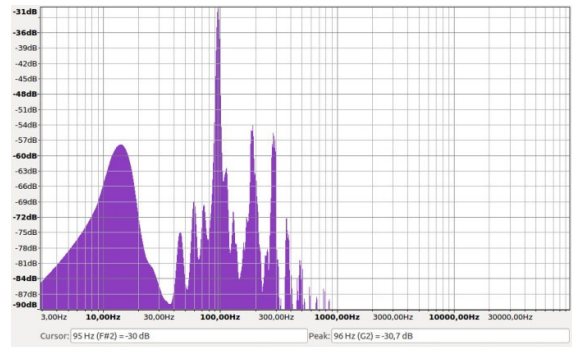


Figure 11 – The chamber resonance stimulated by male voice. The big peak around 95-96Hz is really evident.

The slight difference that exists between the resonance peaks is due precisely to the different characteristics of the instruments used which have different superior harmonics, but which also stimulate the resonance of the room around the same frequency. So it is possible to say that by drum and voice stimulation the resonance frequency of the room is between 95 and 98 Hz, that is a very narrow band of frequency, so absolutely not random. These results suggest that the separation in two rooms, upper and lower, is therefore the result of a renovation, because a wooden floor interposed between the two rooms would have made a resonance response of this type impossible. It is easier to assume that the original structure was composed of a single chamber. It is also interesting to verify in the graphs the presence of a more rounded peak before the vocal frequencies, due to the natural vibration already identified in the whole area of the Pyramid of Bomarzo, always located at 14 Hz. The room also has a second, less intense resonance frequency, set at 109Hz. This phenomenon is not uncommon for the hypogean structures already studied by us in Malta [9] and in Cividale del Friuli [7]. Both resonance frequencies have greater effect if you place yourself in the west corner of the room. The last graph (Fig. 11) represents the infrasonic vibration already highlighted above, but at 0db of sound recording, that is the same recorded volume in open air kept at the Bomarzo Pyramid and in the area above the Finestraccia.

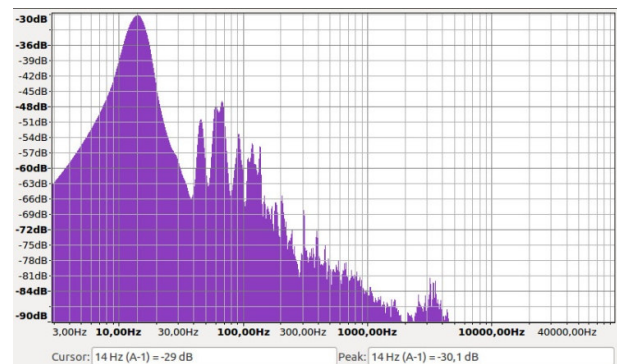


Figure 11 – The graph of the sounds taken in total silence inside the rock structure. We found this peak of infrasound at 14Hz in the whole area, but here at a much higher volume (-30db).

The Fig. 11 represents the graph taken in the silence of the room. In it the infrasonic frequency already highlighted and placed at 14Hz has, however, a volume of -30db, which is to be considered very high. This rock structure is likely to act as a sound box for the frequencies coming from the subsoil.

A greater problem, however, is represented by the radioactivity of this place, which is around 0.46 $\mu\text{Sv/h}$ peak, probably due to the poor air exchange present in the rock structure, unlike the places in

the open air previously examined. So it appears that, staying in this place for a long time is not advisable, but a short stay inside this structure does not create health problems. Sievert is the unit of measurement of the "equivalent radiation dose" in the International System. It is a measure of the effects and damage caused by radiation to an organism. The Sievert replaced the old traditional unit, the rem ($1 \text{ Sv} = 100 \text{ rem}$). In Heidelberg (Baden-Württemberg, Germany), where the used equipment was built, the natural background radiation is within a range of 0.10 and 0.20 $\mu\text{Sv/h}$ (microSievert/hour). In Finland, the natural background varies from 0.04 to 0.30 $\mu\text{Sv/h}$ and the alarm threshold is set at 0.4 $\mu\text{Sv/h}$. Values above 0.60 $\mu\text{Sv/h}$ reveal the presence of a radioactive source. Recall that a simple chest X-ray exposes us to 1,000 μSv (microSievert) in a single dose, a TAC of 3-4,000 μSv .

The surrounding areas, both the access road and the nearby road, equally examined, do not have these characteristics. So we have to consider them as peculiar to this area.

5. Discussion

There is no doubt that the district of the 'Pyramid of Bomarzo' possesses characteristics typical of the sacred sites we also examined before in various European and Asia Minor locations. The presence of 14Hz almost everywhere, even if at different volumes, is a characteristic we have often encountered, for example in the sacred site of Sogmatar in Turkey, in the so-called Temple of the Seven Planets [14] and in Enclosure D at Göbekli Tepe in South Anatolia [20] where it was also possible to find a magnetic field equally powerful to that in the Pyramid of Bomarzo. In the silence it was very easy to record this strong natural frequency coming from the subsoil of about 14Hz, which was also outside the rock structure, but which has the maximum power within it, for the ability to transmit sound of the rock, which acts as a natural transducer. It is important to remember that this frequency is present in other holy places in Europe, which has a strong effect on brain waves, capable of inducing a state of relaxation [10,12,13,18]. It will be very interesting to come back to the site in the future, to examine the effect using more sophisticated devices, as previously done in other sacred sites, for example in Italy or in Slovenia [16]. At the end of each research, many questions arise spontaneously. How these phenomena were known millennia ago? How is it that millennia ago the Rinaldonians, the Etruscans and the ancient Romans managed to find the sacred places without using the measuring devices we have today? We know from historical sources that the Roman architects had a deep knowledge of the vibrations coming from the subsoil and possessed a particular category of priests called "Augurs" that had the ability to detect such vibrations using various methods of divination. These techniques were used to find the optimal position for a military camp, a public building or a spa, taking care to avoid any potential negative impact on health [16] and the Romans had a deep respect for them. It is believed that the knowledge of the use of thermal waters was originally held by the Etruscans, as a lot of knowledge and techniques generally attributed to the Romans. The Etruscan 'Discipline' was a compendium of knowledge, probably derived from very remote times, which included the 'Knowledge of Heaven and Earth', held in high esteem in Rome. The books of the Etruscans did not reach us, but were kept in the temple of Jupiter in Rome for many years and then destroyed by the Romans before and after the arrival of Catholicism. The Roman nobles sent their offspring to Etruria to be educated by that cultivated and refined people, to whom we owe so much of our history, even if their wisdom is usually attributed to the Romans, according to a *damnatio memoriae* that lasts to this day. The Augurs were a class of priests; Tito Livio wrote in his book "Storia di Roma", Book VI, that no decision on war or peace was taken in ancient Rome before consulting their council [24]. Tito Livio also wrote in Book I that this college was made up of fifteen members initially chosen by the dictator Silla, whose decisions did not concern the future, but the approval of the Gods [25]. These decisions could be considered as a preliminary feasibility study for any activity to be undertaken. Augurs have always been considered as a special group of priests within a larger group called the "Aruspici". Their task at the time of Etruscan culture was to interpret and understand the general will of the Gods. Some historians like Squadrilli [26] place this tradition since the time of Romulus, who would have used it for the foundation of Rome.

Augurs are associated with the interpretation of the flight of birds. They carried a characteristic stick with the tip bent like the handle of an umbrella, called "lituum", whose function was to limit the number of birds seen in the sky, so that their behavior could be observed with care. This was considered as a mere superstition, but it ignores how much birds are noticeably sensitive to environmental factors. Few people remember that this particular object was also used as a 'diviner's rod' and many Etruscan tomb paintings show priests carrying the lituum during specific ceremonies, attesting that the auspicious art was already known and widely used by this people, before Rome made it his own. In medical science it is well known that in humans the palms of the hands, feet and in the thorax there are vibratory receptors, the so-called Meissner sensors, capable of detecting inaudible vibrations [16]. It is evident that personal experience and training were important so that the ancient wishes could effectively determine where the best conditions existed for positioning a temple. In modern times these studies are rediscovered in the field of bio-architecture, which takes into account the geo-physical characteristics, the position and the surrounding environment before each construction, in order to avoid the onset of geopathic stress. The powerful magnetic field present on the Pyramid of Bomarzo is, however, a topic still to explore further. It is a field that attracts, but to determine what the direct effect on brain activity will be would require further studies with the use of volunteers undergoing the examination of a portable EEG (electroencephalograph). In the future, our research will continue in this direction. The hypothesis is that it is the shape of the pyramidal structure that acts as an amplifier of a pre-existing natural phenomenon.

It is certainly not random that we found resonance inside the structure carved in the rock placed next to the pyramid. It has to be considered as a temple and not only a rock shelter. The frequency of resonance can be stimulated by a voice and by the drum, that together with the flute are the most ancient musical instruments, fall within the range of 80-140Hz; this frequency is able to provoke a modification of the state of conscience. We have demonstrated this effect several times in the laboratory [5,15,23]. This type of frequency modifies the nervous activity, causing in some brain centers a doubling of the frequency, a phenomenon that allows the subject subjected to these frequencies able to experience a lucid dream if properly trained. In fact, the ancient sacred places were not for everyone, but only for people who had practiced special meditation or prayer techniques. In people who are not trained in meditation, these frequencies provoked only a strong emotionality or a marked state of relaxation. This phenomenon made the rituals inside the structure more suggestive for sure.

6. Conclusions

It is very important to understand the relationship between these ancient sites and the people who built them. So archaeoacoustics should not only analyze the acoustic properties of the site, but also all the physical phenomena associated and not perceived by the human ear, which could have influenced the archaic populations in considering a particular place as sacred. The archaeoacoustic analysis of the Pyramid of Bomarzo provides various evidence to support the hypothesis that the decision to choose that site as "sacred", by reshaping the huge block of magmatic rock, was not accidental. The discovery of the magnetic field centered on the 'Pyramid' that could be the desired or unconscious result of this modification, but which has accentuated the natural phenomenon able to alter the state of conscience. A very important discovery is the resonance phenomenon inside the rock structure called 'Finestraccia', which should therefore be considered as a temple and not as a simple residential structure. It must be remembered the carving in rock is not the most primitive system with respect to the construction of a structure on soil. On the contrary, an error in the development of the hypogeal structure cannot be remedied, so that the exact pitch of the chamber in the 80-140Hz range presupposes a profound knowledge, even if empirical, of the shape necessary to obtain this phenomenon and assumes a very advanced culture. This type of phenomenon refers to the hypogeum of Hal Saflieni in Malta, built around 4000 BC. and remained almost unaltered even to present day [9]. It is therefore conceivable that this technology based on the knowledge of the relationship between mind and sound, was the common heritage of various civilizations that

inhabited the Mediterranean basin at that time. Consequently, it is conceivable, without fear of speculative impulses, that there were cultural exchanges between those populations. These results must be considered as preliminary, the research must therefore be extended and deepened in the years to come.

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