

Archaeoacoustic Analysis of the Hal Safleni Hypogeum in Malta

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Abstract

Recently we studied the acoustic properties of the underground Hal Safleni Hypogeum in Malta. Identified as "architecture in the negative", it is a unique prehistoric complex, intentionally sculpted with features that mirror megalithic temples above ground. It is known that the Hypogeum was used in the Neolithic not only as a depository for bones, but also as a shrine for ritual use. In a room known as the "Oracle Room" set in the second level of the hypogeum, we have been able to detect the presence of a strong resonance effect: a double resonance frequency at 70Hz and 114Hz. With a male voice tuned to these frequencies it is possible to stimulate the resonance phenomenon throughout the hypogeum. It was further detected that percussion instruments can stimulate the resonance by their harmonics. Laboratory testing indicates that these frequencies have a strong effect on human brain activity. Since it is likely that the chambers served as centers for social or spiritual events, the resonance of the chamber cavities would have supported human ritual chanting and mystic consciousness.

Keywords: Archaeoacoustics, Hal Safleni, hypogeum, resonance, brain activity, megalithic architecture

Introduction

Archaeoacoustics is a recent interdisciplinary field of study, using different parameters to examine ancient sites for overlooked technology that operates on the human emotional sphere. Archaeology has most often focused on visual appearance and physical objects, although the past was not a period of silence.

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The intent of archaeoacoustics is to explore the importance of sound in the past and in particular its role in the development and design of ritual architecture and its possible impact on the biological activity of the human brain.

The purpose of this paper is to verify the ability of Neolithic builders to manipulate sound in the archaeological site of Hal Safljeni and the real weight of physiological impact from acoustic phenomena in this hypogea by using new technologies. Since this UNESCO World Heritage site has to follow concise rules for conservation, we had only the possibility to focus our research in the so called Oracle Room.

Research over four years by SBRG⁴ has shown that several ancient populations were able to influence their perception of the human body using sound to obtain different states of consciousness, without the use of drugs or other chemical substances. Further, ancient people were able to detect natural phenomena to create a similar state of altered consciousness (Debertolis & Savolainen, 2012; Debertolis & Bisconti, 2013a; idem, 2013b; Debertolis, Mizdrak & Savolainen, 2013; Debertolis, Tirelli & Monti, 2014; Debertolis & Bisconti, 2014).

SBRG is also concluding a new study in collaboration with the Otorhinolaryngology Clinic and the Clinical Neurophysiological Service of Department of Neurology in Trieste (Italy) for the assessment of the effects of resonance phenomena on the human body (Debertolis, Tirelli & Monti, 2014). Volunteers underwent examination by EEG while listening to tones between 90Hz and 120Hz, similar to the resonant sounds present in some Neolithic structures in Europe (England, Ireland, Italy, and Malta). The preliminary results confirm that those frequencies have a strong effect on human brain activity (Debertolis, Tirelli & Monti, 2014). These last studies follow similar research carried out inside megalithic chambers from the UK, arguing that brain activity at 110Hz is significantly reduced in language centres, allowing other processes to become more prominent (Cook et alii, 2008). According to P. Devereux (2006) this kind of brain activity is associated with the half-awake/half-asleep hypnologic state with vivid mental imagery and auditory hallucinations.

⁴ SB Research Group (SBRG) is an international and interdisciplinary project team of researchers investigating on archaeoacoustics of ancient sites and temples in Europe

Archaeoacoustics, as mentioned before by several authors (Errico & Lawson, 2006; Scarre, 2006), has similar methodological problems with Archaeoastronomy regarding the determination of deliberate actions by prehistoric human beings, or the intentionality of their monument building acts (Coimbra, 2014). However, as C. Scarre (2006: 9) referred, "the archaeoacoustics of prehistoric contexts is potentially a vital part of the understanding of the lived experience of past societies".

The Maltese Hal Saflieni Hypogeum

It's generally accepted that the first time man arrived on the Mediterranean islands of Malta was in 5,200 BC. Through archaeological excavations and the use of carbon 14 dating, the construction there of a number of megalithic temple complexes is placed from around 3,600 BC (Pace, 2004). Many researchers have tried to analyze and study the Maltese temple building culture. The most widely known were: Zammit, Ugolini, Ceschi and the British archaeologists Trump and Evans.

The Hal Saflieni Hypogeum is an underground complex dug into the rock. It was accidentally discovered in 1902 during construction work and had been undisturbed until then, from the time of its abrupt disuse (around 2,500 BC) by the culture that made it. The first description of eerie sound behavior and odd echoes in the site came in 1920. Writing for the *National Geographic Magazine*, William Arthur Griffiths pointed out that "Here it was noticed only a few months ago that any word spoken into this place (the Oracle Room) was magnified a hundred-fold and audible throughout the entire underground structure. A curved projection is specially carved out of the back of the cave near this hole and acts as a sounding-board, showing that the designers had a good practical knowledge of sound-wave motion. The impression upon the credulous can be imagined when the oracle spoke and the words came thundering forth through the dark and mysterious places with terrifying impressiveness" (Griffiths, 1920: 465).

The complex consists of a system of chambers and passages that develops into three distinct underground levels until reaching a maximum depth of about 11 meters and covering an area of about 500 km². From first glance this immense work seems to be the result of a well organized and advanced civilization. The Hypogeum is known to date back to at least 4.000 B.C., if not slightly earlier. According to Pace (2004) Zebbug Phase pottery from this period has been discovered on site.

Amazingly, the rock was excavated using only simple tools made of bone or hard stone. According to Carbon 14 dating the Hypogeum was used over a span of many centuries during which the monument experienced a large number of modifications (Pace, 2004). The architecture of this hypogeum features a curved shape such as an *apsis cellae* of the surface temples. It is remarkable to see the deliberate choices made in the excavation of the chambers which would easily have allowed other more spontaneous and rational solutions. It is full of arches, vaults and domes (Ceschi, 1939). The pseudo-façade in the area known as Holy of Holies even suggests a temple.

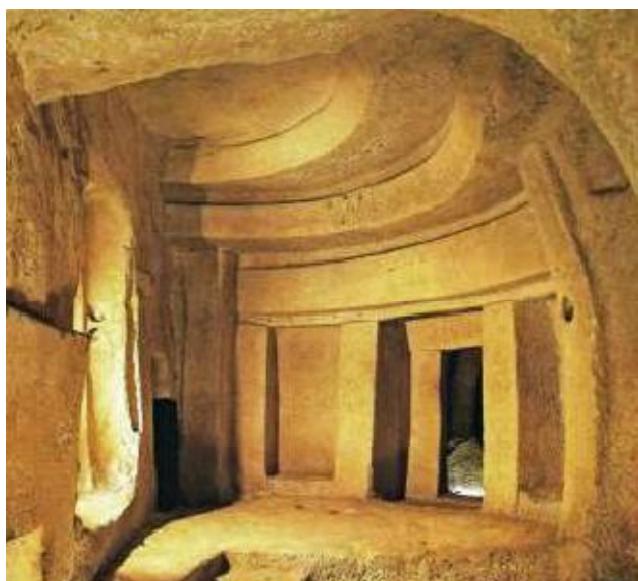


Fig. 1: The Central Hall of the Hypogeum (Photo: Archival MTA)

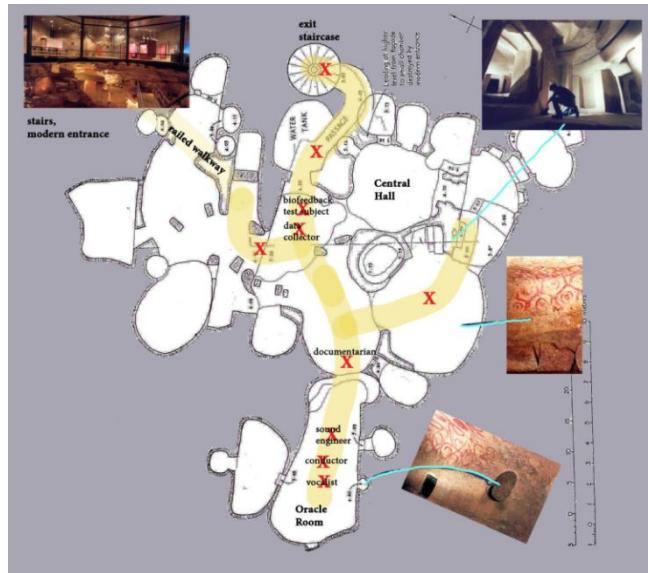


Fig. 2: Map of the Maltese Hypogeum Hal Safleni . At the Bottom of the Map is the Oracle Room, where the Experiment was Made

The Maltese hypogeum played two roles, the first as a sanctuary dedicated to worship, possibly of a Mother Goddess; the second as a burial place, as evidenced by the remains of thousands of skeletons with their ornaments and their pottery. It has been hypothesized by Evans (1971) that the interconnected holes in the floor in front of the entrance to an area known as the "Holy of Holies" could have been used to collect the libation of animals destined for sacrifice, or for solid offerings, with rope being run through the holes. This feature is also found in the ground outside the entrance to the above ground temples.

Some of the holes in the walls of the hypogeum chambers are attributable to the practice of oracles, as it happened at Delphi many centuries after. It is plausible that a priest took advantage of the echo phenomenon and resonance, answering anonymously any questions that were asked. The most interesting example attributed to this fascinating practice, is inside the "Oracle Room". Speaking from a niche carved inside this room, the voice is greatly amplified and deepened. Evans had already noticed the acoustics of that niche, mentioning that "undoubtedly a deep echoing sound can be set up by speaking into it" (Evans, quoted by Devereux, 2009: 227). There is also a second niche which seems also to have importance as regards this effect.

This chamber seems to be the center for generating resounding echoes that continue into other parts of the Hypogeum with a pinball effect. At the right frequency, there is an amplification not only of the sound but also its duration. During our experiments, it was reported that some sounds in the Hypogeum reverberated (or echoed) for as much as 7 or 8 seconds after the original sound had stopped. These would be the resonant frequencies.

The word resonance comes from Latin and means to "resound" - to sound out together with a loud sound. Resonance is a common cause of sound production in musical instruments. In this case, instruments are set into vibrational motion at their natural frequency when a person hits, strikes, strums, plucks or somehow disturbs the object. Each natural frequency of the object is associated with one of the many standing wave patterns by which that object could vibrate.⁵ In physics, resonance is the tendency of a system to oscillate at greater amplitude at some frequencies than at others. These are known as the system's resonance frequencies. At these frequencies, even small periodic driving forces can produce large amplitude oscillations, because the system stores vibrational energy.⁶ Hal Safleni's Oracle Room responds with highest aural effect to frequencies within a range that can be sung by a bass or baritone voice.

A radio frequency spectrum engineer who was with our group observed that "The Oracle Chamber ceiling, especially near its entrance from the outer area, and the elongated inner chamber itself, appears to be carved into the form of a wave guide. The very low frequency sounds that echo strongest in the Hypogeum have very long wavelengths, thus the wave guide employed would need to be quite large. "I believe The Oracle Chambers' size itself is of the magnitude as to create the wave guiding effect upon the sound waves produced within." (Kreisberg, 2014). Also Trump had noticed that the end wall of the Oracle Room has the evidence of the carving of a projecting ridge that "might have been specially made to carry the sound" (Trump, quoted by Devereux, 2009: 227).

⁵ <http://www.physicsclassroom.com/class/sound/Lesson-5/Resonance>

⁶ <http://www.ask.com/question/what-is-the-definition-of-resonant-frequency>



Fig. 3: The Oracle Room, Looking Outward, before the Insertion of the Footboard for Visitors. It is Possible to see the two Mentioned Niches and Prehistoric Paintings (Photo: Heritage Malta)

Another important aspect of the Hypogeum is the presence of red ochre prehistoric paintings, consisting essentially of intricate spirals, some disks and other geometric patterns, which certainly had a symbolic meaning. They may have been related to funerary rituals, to worship or both. It is not our intention here to make an interpretation of these figures. However they may have been related with the acoustical properties of the Hypogeum (Coimbra, 2014). As a matter of fact, they seem to be associated with the second niche after the entrance, that has itself three painted red disks on its inside surface. The intricate spirals and disks, smaller near the entrance of the room, grow larger in size when approaching this niche and stop just before reaching it. Paul Devereux argues that the niche had the function of a speaking tube of some kind, for oracular or other purpose" (Devereux, 2009: 229), also mentioning that "spirals are indeed suitable visual analogues for sound" and that "the increasing sizes of the spirals and especially of the disks could signal amplitude - i.e., the special acoustic qualities of the niche" (Devereux, 2009: 230).

Certain kinds of sounds seem to have a large influence on the emotional processing of individuals. For example, hearing traditional mantras, or a non-semantic sound used in meditation has an effective influence on human brain activity, which has been shown in scientific publications (Xu et al, 2014). During the last experiments in the Hypogeum, the sound of a horn played in the Oracle Room was felt crossing the body of one of us (F. Coimbra) at high speed, leaving a sensation of relaxation, while standing in front of the prehistoric paintings in room 20. After some minutes, that instrument was played again and the result was similar but even more relaxing, accompanied by the illusion that the sound was reflected from the author's body to the walls⁷.

Now some questions arise:

- Did Neolithic human beings feel similar body sensations, caused by sound, at the Hal Safleni Hypogeum or elsewhere?
- Could the prehistoric paintings from the Maltese Hypogeum be the "depiction" of eventual bodily experiences caused by sound and related imagery?

In order to answer these questions in a more objective way, further research must be done, not only at Hal Safleni but also at other Neolithic chambers from Europe, especially in those that have megalithic art on their walls and sound reverberations with a frequency around 110Hz (Coimbra, 2014).

Materials and Methods

The experiment was carried on over several hours on the 21st of February 2014, specifically in the Oracle Room in the main level of the hypogeum. Gathered by the help of the Old Temples Study Foundation (OTSF), a multidisciplinary group of researchers aimed to explore the phenomena of sound (human voice or musical instruments) generated in this room in the well-known 'node of resonance' as it was indicated by previous researchers during past investigations (Evans, 1971; Trump, 1981; Devereux, 2009). We were positioned close to the first niche on the left of the entrance of the Oracle Room. This is the optimum position to achieve a resonance effect, which allowed the frequencies to expand in every chamber.

⁷ It can be argued that this is a subjective state of mind. However, a similar experience was felt by another researcher at the prehistoric chambered monument of Maeshowe (Coimbra, 2014), being then important starting to gather this kind of information.

Research was conducted in darkness or very low light, necessary for conservation of the ancient paintings in the site. We used SBRG's recording equipment and high-end microphones used in previous missions in Europe. The equipment consisted of two dynamic high-end recorders extended in the ultrasound field with a maximum sampling rate of 192 KHz (Tascam DR-680) or sampling rate of 96 KHz (Tascam DR-100). The microphone equipment was provided with a wide dynamic range and a flat response at different frequencies (Sennheiser MKH 3020, frequency response of 10Hz - 50.000Hz) with shielded cables (Mogami Gold Edition XLR) and gold-plated connectors. Another digital recorder (Tascam DR-100) was placed on a tripod outside the Oracle Room for recording the diffusion of the sound outside the chamber. All recordings were performed according to the Standard SBSA protocol for archaeoacoustics (Debertolis, Mizdrak, Savolainen, 2013).



Fig. 4: The Microphones were Placed in the Center of the Room on two Tripods set within the Limit of Railing, so the main Recorder (Tascam Dr-680)

Before all we recorded the background noise coming from the neighbourhood of the hypogeum. We have to remark that the hypogeum is below some houses of the Maltese town of Paola. But nothing of interesting was noticed.

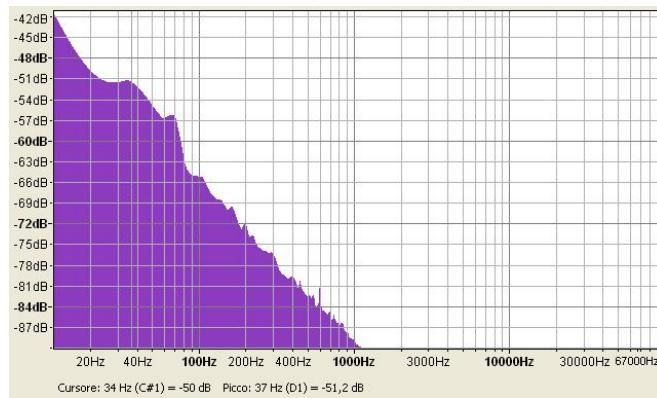


Fig. 5: The Baseline Sound of Hal Safleni Hypogeum: Nothing to Remark, Just a Little Noise from the Neighbourhood, but at Very Low Volume

In the interest of replicating conditions present in ancient times, male voice was used, such as for singing or praying, which included vocalization at the target 110Hz frequency. This frequency equates with A2 on a modern musical scale and falls in the range of a baritone. A female voice was also tested. Then we used some traditional musical instruments which could have been present during the time the hypogea was in use. Thanks to the knowledge of the Maltese musicologist, Anna Borg Cardona, the following Maltese instruments were used in this experiment:

- The large Mediterranean marine shell **Charonia Lampas**, known as *bronja*, with apex chipped off. It measures: 280mm long x 150mm wide, apex diameter 25mm. Several fragments of *Charonia* shells have been excavated from prehistoric sites on the Islands.
- A bull horn with an added reed mouthpiece, known as **qarn** or **qrajna**. Horn 20mm long x 75 mm at its outer serrated edge. Pointed end is sawed off and an *Arundo donax* downcut reed inserted. Animal horns have been found preserved in prehistoric sites inside sacrificial altars and seem to have been endowed with some special significance.
- A friction drum known as **rabbaba** or **żafżafa**. This is a Maltese traditional folk instrument. It consists of a clay pot 210mm high x 150mm diameter at base x 210mm diameter at top open end. Stretched over its open end is a goatskin, fur side up. Into the centre of the skin an *Arundo donax* rod 600mm high has been securely tied. Vibrations are produced by rubbing the rod with a damp sponge.



Fig. 6 – Top: The Marine shell Charonia Lampas, known as Bronja. Below: The Bull Horn with an Added Reed Mouthpiece, known as Qarn or qrajna



Fig. 7 – The Maltese Traditional Folk Instrument Friction drum, known as Rabbaba or Žafżafa

The last musical instrument was a percussion instrument that is known as "Irish drum" or also as "shamanic drum" still commonly used today in Celtic music performed in Northern Europe. This ancient drum is found in virtually all cultures of the world and is still made today. The materials would have been available in the Neolithic period corresponding to the construction of the Hypogeum. It is a drum with one head, built on a circle of solid wood on which is stretched an animal skin, typically goat or deer, but skins can also be derived from different animals, depending on the area and culture. The sound of this instrument is deep, but if the skin is damp from moisture, the tone changes as it vibrates less. The skin needs to be dry to produce the correct sound. So the sound can change very quickly and is conditioned by the environment. If this is humid then the skin needs to be heated over a fire in order to obtain a more pure sound. For our research we used a shamanic drum with a diameter of 40 cm made from goat skin.

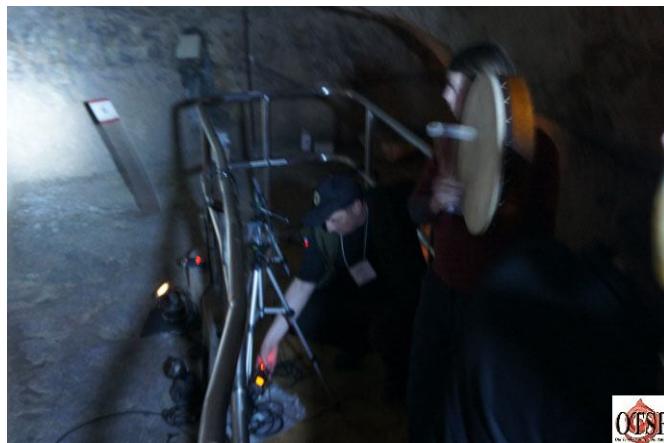


Fig. 8 – The Irish Drum used during the Experiment by our Research Group

The correlation between the sound source and response of the chamber through sound spectrum graphics (using computer audio programs) was verified at the same time as the singers voice vibrations were being correlated to the response of the chambers. PRO TOOLS ver. 9.05 software for Mac was used to overlap and mix the various recorded tracks, Praat program version 4.2.1 from the University of Toronto and Audacity open-source program version 2.0.2, both for Windows PC. The singers performed a repertoire of ancient chant and overtone singing. It was found that mantras and modulated frequencies typical of various mystical songs and prayers excited the surrounding structures at particular frequencies.

Results

We detected that the male voice can stimulate the resonance not only at 114Hz, but also 68-70Hz. So there are two frequencies that could be used for having a strong effect during rituals in the Hal Safleni Hypogeum. This is a bit different from the 110/111 Hz that was initially expected, based on previous research in other Neolithic chambers (Cook *et alli*, 2008), but still within what has been called "the megalithic range" of resonant frequency found in similar stone sites (Jahn *et alli*, 1995; Debertolis & Bisconti, 2013).

The base line of frequency for male voice has a range from 77 Hz to 482 Hz (Stemple *et alli*, 1994), although a trained male voice can go as low as 70Hz. In fact our singer was able to reach this frequency, as can be seen on the graph. High volume of the voice is not required for the stimulation: a weak voice at the right frequency can have a good effect.

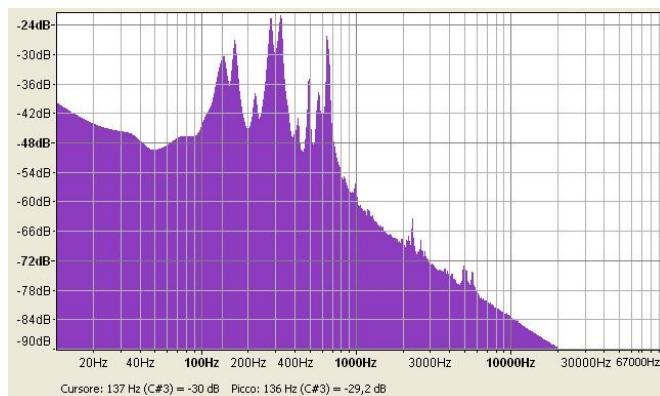


Fig. 9: The Plot of the Voice of the Singer during Normal Extension. It is Possible to see the Harmonics of Male Voice Expanding in the Oracle Room

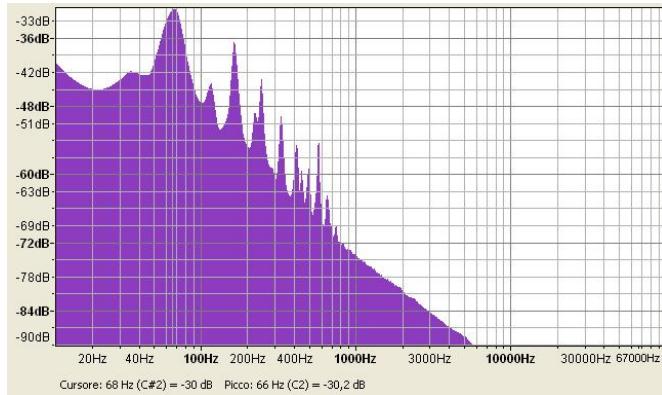


Fig. 10: If the Singer arrives at 68-70Hz the Chamber Strengthens the Voice by Resonance effect. In fact it is Possible to see a Large Peak Around this Frequency not Present at Different Frequencies

The shouting voice of either male or female, does not expand itself a lot in the hypogea. In the graphs it is possible to see the different extension, but with a hole of frequencies before and after the harmonics.

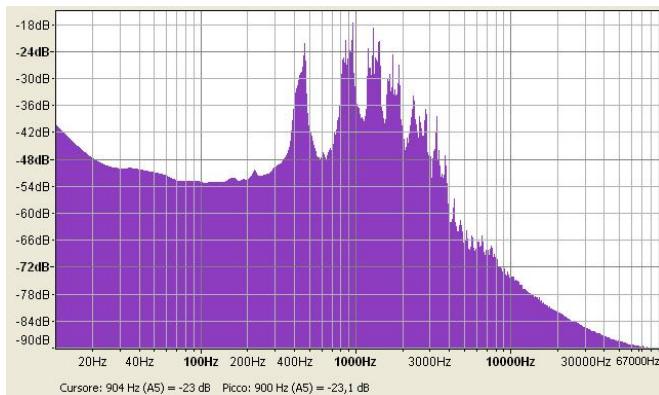


Fig. 11 : The Harmonics of a Male Voice during Shouting. There is a hole of Frequencies before and after, Corresponding with no Response of the Hypogea. The Peak is around 900Hz

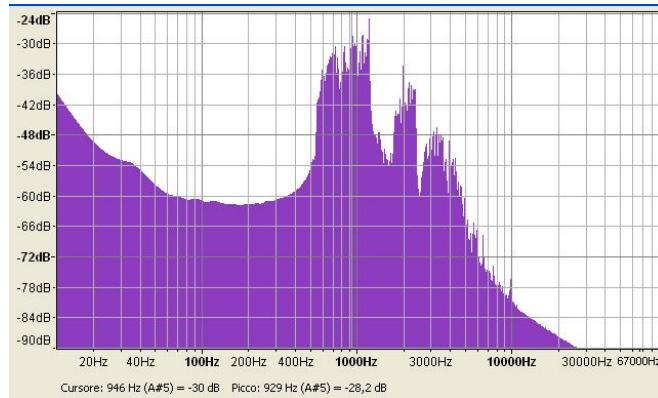


Fig. 12: The Female Shouting Voice looks similar to the Male Shouting Voice: No Response from Hypogeaum. The Peak is around 929 Hz

With the use of the instruments, the effect was not the same. In particular the sound of the conch shell was very strong, but not able to stimulate the structure.

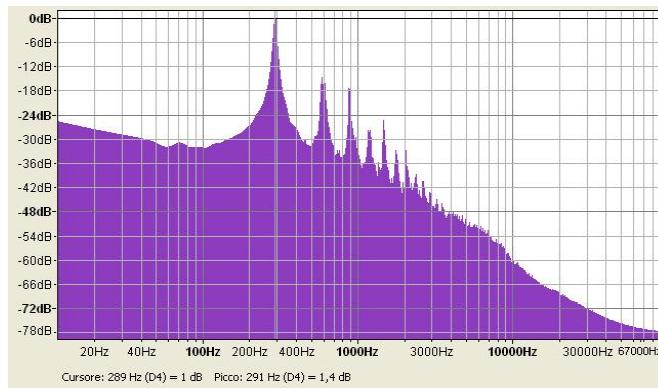


Fig. 13 – The Conch shell has a Strong peak around 290Hz, but too High to Stimulate the Structure

As mentioned before, the sound of a bull horn played in the Oracle Room was felt crossing the body at high speed, leaving a sensation of relaxation in some researchers present at the experiment.

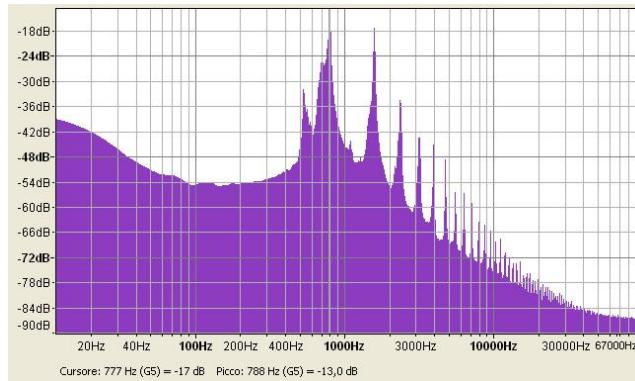


Fig. 14: The bull horn. The Graphic doesn't show any Activation of the Structure, but it is Extended also in the Ultrasound Band

Curiously, the recordings didn't indicate activation of resonance in the Oracle Room by the bull horn. However, the sound of this instrument was "felt" intensely. This is probably because this instrument has an extension in the band of ultrasounds. Future analysis of this effect in the hypogeum is indicated because ultrasound has a direct effect on the human body, and the reflection of sound waves by the walls of the hypogeum was very strong in this experiment. The friction drum obtained only a partial effect of resonance stimulation. This is because the model we used in the hypogeum was not tuned up at the right target frequency (114Hz). Our friction drum had instead a base frequency of 109Hz. So it stimulated the resonance of Oracle Room only partially. We can suppose that with the right instrument the effect could be very, very strong.

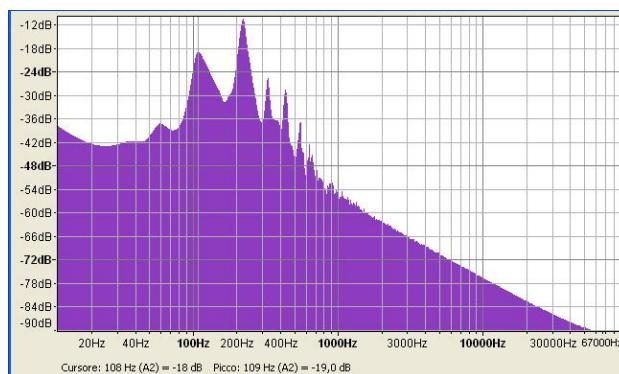


Fig. 15: The friction drum partially stimulated the structure. In fact it is possible to see a second peak out of the normal harmonics of the instruments around the frequency of resonance of the Oracle Room (114Hz)

The Irish drum, or shamanic drum, obtained the best performance in the Oracle's Chamber. Its harmonics were able to stimulate the structure very strongly at 114Hz and 70Hz. But it is important to have a high volume pressure for good response. If the drum is hit by soft hand instead of by a ram there is low resonance effect from the structure.

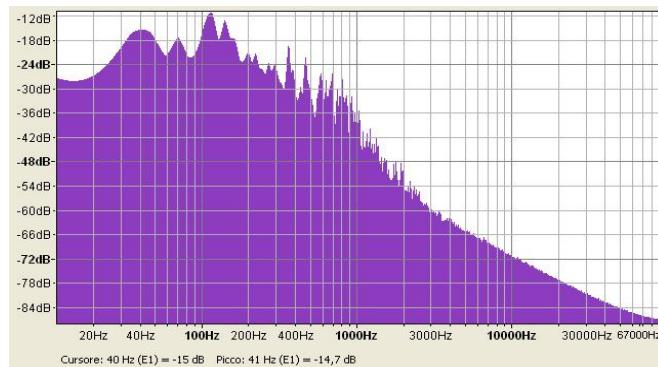


Fig. 16: The hit on the Irish drum that has a base Frequency around 40Hz

But if the hit is sufficiently strong, the response is very impressive, because the structure responds as it does to a male voice saying "oooh". This is an amazing effect that is particularly evident if we compare the graph of the hit with the graph of the voice response of the chamber.

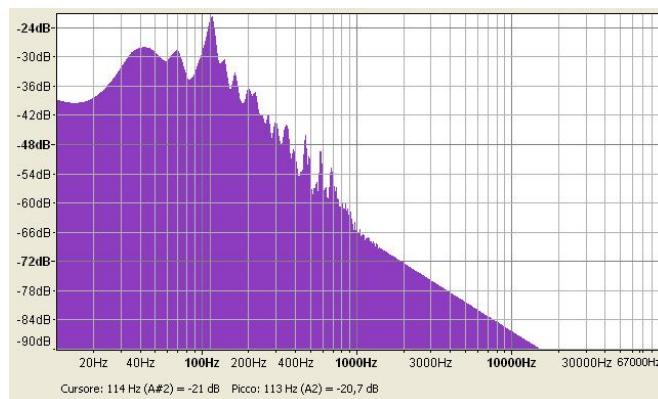


Fig. 17 – Immediately after the hit, the room gives its Response at 114Hz and just a little around 70Hz

If the drum is hit only with the hand without a strong pressure the effect is less. The peak of the response of the room at 114Hz is also less if the peak around 70Hz is more evident.

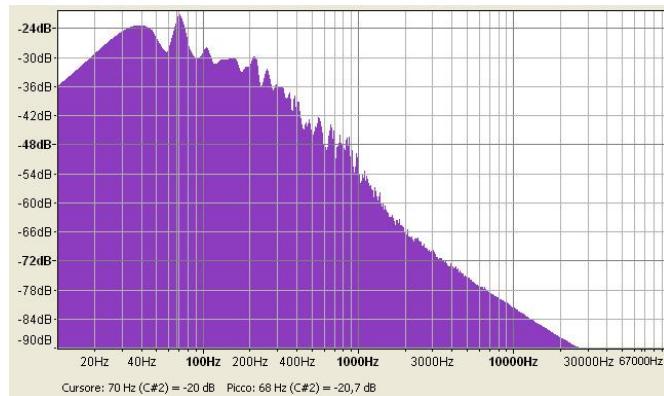


Fig. 18: The Soft Hand on the drum has Less Resonance Effect

Discussion

We discovered that the response in the Oracle Chamber is highest at 114Hz and 68-70Hz, so at these frequencies it is possible to activate the greatest resonance of the structure by male voice during chanting or singing. Also the frame drum (Irish or shamanic drum) can stimulate the resonance by its harmonics at the right rhythm and at the right sound pressure. The same happens with a friction drum, an ancient Maltese instrument, if tuned at the right frequency. We cannot rebuild the rituals made in this hypogea, but we are able to imagine that the music and some singers had a strong role in them. Further, these resulting frequencies have a direct effect on the human brain that presents a striking aspect for rituals (Debertolis, Tirelli & Monti, 2014).

The intentions of the Neolithic makers of the underground mortuary shrine can never be fully known, but it is naïve to think that ancient people failed to notice, or would not have used the sound effects of the place in some way (Eneix, 2014). The carving of the two niches which concentrate the effect of sound, the curved shape of the Oracle Chamber with its “shelf” cut high across the back, the corbelled ceilings and concave walls that are evident in the finer rooms are all precursors of today acoustically engineered performance environments. Their development seems not to be by chance.

Although the know-how of the Hal Safleni builders was empirical, it need not diminish their ability to manipulate a desired human psychological and physiological experience.



Fig. 19 – The Test with the voice in Oracle Room. This photo has been bEnhanced as far as Possible from a Video Capture

Only minimal lighting was permitted, for protection of prehistoric paintings.

Conclusion

At the end of this paper we can conclude that we have reached our opening purpose for better defining the acoustic aspects of Hal Safleni Hypogeum. New thoughts about the intention of this site's builders has been made possible by a multi-disciplinary approach that includes archaeological and anthropological context as well as acoustic analysis technology. Through new technologies and ancient instruments we confirmed that it is possible to stimulate the phenomenon of resonance in the Hal Safleni Hypogeum not only by a male voice praying or singing, as checked in previous studies, but also by a percussion instrument. So the use of the phenomenon for ritual purposes would not be limited to a male with a low voice, but could equally have been exploited by a female with a drum. This may have significance in the exploration of traditions of a Neolithic Mother Goddess culture and improve the knowledge of the use of this hypogea. Combined with research on the effect of acoustics on the human body, we can say archaeoacoustics is an interesting new method for reanalyzing ancient sites. Indeed, its study presents a chance to recover "ancient knowledge" that affects the emotional sphere of human consciousness, as well as to broaden our understanding of the ancient world.

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