

# The phenomenon of resonance in the Labyrinth of Ravne (Bosnia-Hezegovina)

## Results of testing

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**Abstract—** The resonance phenomenon in Ravne tunnels in Bosnia – Herzegovina is an unusual but unknown phenomenon. A number of researchers consider this structure to be an ancient mine. But in our research we demonstrated a very strong response at 71,57Hz when a singer sings inside the tunnel. Our thesis is that this structure was also used for rituals and prayers, because the resonance of these frequencies can have a direct effect on the human body, in the same way as was found in ancient Neolithic temples in South of England.

**Keywords:** archeology, archaeo-acoustic, resonance, Ravne tunnels, SBRG, SB Research Group, PEAR, Princeton

### I. INTRODUCTION

The phenomenon of resonance is something that has been understood for thousands of years. It is often only partially understood, confused with episodes of mystical philosophy. We find traces of it in ancient writing and oral traditions, and also in ancient artifacts and prehistoric architecture (1).

Although today it appears to be a well recognized phenomenon by physicists and is used in many technologies. Not yet mastered to its full extent, resonance can be found in astronomy or in the world of energies that are determined at the atomic level. Resonance is a research area that appears to have little or no exploration in terms of mechanical, chemical, electromagnetic, biological and acoustic fields (1). However science now appears to be increasingly interested in it to understand certain natural phenomena that have previously been inexplicable.

Without going too deeply into complex physical mechanisms, we can say that resonance is the phenomenon in which an object absorbs energy, transforms it and makes it again in another form, but better. At antipodes of resonance phenomenon we find the entropic energy lost by mechanisms in a chaotic and random system.

Resonance can be found at any level of the cosmos where we find any form of energy. From the movement of the spiral of our galaxy to the oscillations of the electrons of a semiconductor: a phenomenon we can find anywhere and everywhere where we find resonance vibrations. This

phenomenon can influence and control the field of fundamental interactions between energy and matter, this concept concerns the fields of physics, chemistry or biology.

In this article we will examine the acoustic resonance and the particular phenomena of resonance in some ancient structures and in particular in Ravne tunnel (Bosnia – Herzegovina) caused by the emission of sound waves at various frequencies.

### II. THE RESONANCE IN NEOLITHIC AGE

There are several studies that have shown that this phenomenon was known about in the Neolithic Age. Some megalithic civilizations had many resonant features, understood to be used mainly for ritual or mystical reasons.

Among the pioneers of research in this area were the group PEAR (Princeton Engineering Anomalies Research) of Princeton University directed by professor R.G. Jahn. They conducted various experiments in 1994 at six Neolithic sites through the use of electronic sound generators to measure their acoustical properties (2).

The six sites were: Wayland's Smithy, Chun Quoit, and Cairn Euny, in Great Britain.; Newgrange, Cairns L and I, Carbane in Western Ireland. All these sites are dated to before 3,500 BC (2).

The rooms were all bounded by crudely carved stones, but they also had very different configurations, both in size and shape. Newgrange was cruciform for example, others were square or hive or like the petals of a flower.

The acoustical measurements in the six Neolithic sites showed all structures featured a strong resonance of between 95 and 120 Hz (with a wavelength of about 3 m). Despite considerable differences in chamber shape and exterior wall sizes, the resonant acoustic models were very similar with nodes and antinodes interspersed perfectly conforming to the central source of sound. In some cases, the design of the stone inside and outside resembled those of the acoustic models (2).

Since these resonant frequencies are within the range of an adult male voice, the conclusion was that through the use of song and prayer, the chambers resonance efficiency was principally used for ceremonial purposes.

The accuracy of construction however, was not down to

mathematics as in a modern building. Wayland's Smithy (Great Britain) for example, has a cross-shaped configuration with two chambers east and west with a central corridor, the resonance frequency was not the same in the two side chambers. The west chamber which was cuboid in shape, had a resonance frequency of around 102 Hz. The east chamber which was more rectangular, had a resonant frequency of 117 Hz. To produce this unique stereo effect, the source of the sound had to be positioned at the center of the corridor in the middle of two chambers (3).

All six structures examined by PEAR presented a resonance of around 110Hz. In some cases it appeared that some of the megalithic stones had been erected and positioned intentionally to improve the acoustic properties of the chamber. This indicates a strong understanding of acoustic properties and resonance phenomenon in ancient times (3).

It should be considered that the search by Jahn and collaborators was not the only such research in this field. Research on British Neolithic burial mounds by Keating and Watson of Reading University, also widely cited by Corliss in his catalog of archeological anomalies (5), is worthy of note.

In 2012 our research group (SBRG) also analyzed the site of Wayland's Smithy and confirmed the presence of resonance phenomenon with the particular characteristics found before by PEAR of Princeton University.

We tried also with percussion instruments, but the best effect is found when the human voice is used, especially with a male voice with low continuous frequencies (for instance "ohmm")

This resonance effect has a strong action on brain waves, making it easier for example for anyone to reach a state of mystic exaltation or deep meditation, as found by American researchers of PEAR group.

It is important also to cite archaeological sites of ancient Greece such as theaters, Neolithic tombs and the famous Hypogeum in Malta. Alongside painted musical stalactites in caves inhabited in the Paleolithic period and the curious stones "noise" in Southern California used by the ancient Native Americans for rituals (5).

Armed with this background and our previous experiences we opted to study the Ravne tunnels (Visoko, Bosnia-Herzegovina). These were considered by some to be very old mines perhaps of the Neolithic period, but without valuing it as a very special temple, where ceremonies could have taken place.

### III. THE RAVNE TUNNELS

This is a series of tunnels dug into conglomerate in ancient times located close to Visoko (Bosnia-Herzegovina). We will discuss how much of the structure has been extensively altered at various times.

It is certain that in the 1960s during the period of ex-Yugoslavia, the tunnels were modified as originally designed by miners in search of a water source for farmers. On that occasion a perforated pipe was placed just below the floor for a hundred meters and was capable of collecting all the water

coming through the walls that collected at the bottom of the tunnels.

The tunnels were also propped up in a large part and it is conceivable that the original Gothic arch shape was enlarged and modified in several locations.

Similarly, in recent years large buttresses topped by wooden planks were used to make the structure more safe for visitors by preventing falling debris. This again has changed the original appearance.

At approximately 250 meters from the tunnel entrance, we found other sections that had been mysteriously closed with earth up to the ceiling, as well as a large part of the side tunnels that lead from the open path. The reason for this seal is not known and our research group (SBRG) made several assumptions, not really supported by concrete evidence.

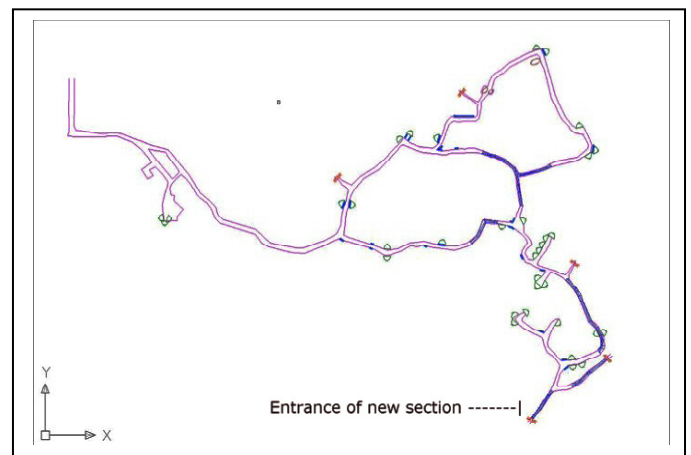


Figure 1. Map updated in July 2011 of the Ravne tunnel (compiled by arch. L. Krsasovec Lucas - Politechnic of Milan, Italy). The experiment was performed at the entrance of new section discovered in December 2010.

Since 2007 the Foundation of the Bosnian Pyramid of the Sun, which has the government grants to carry out the archaeological excavations, proceeded to remove this seal to unearth large tracts of previously inaccessible tunnel.

At the end of 2010, the work of volunteers and Foundation workers, reached an unexpected result. Prior to the de-sealing of the last sections of the tunnel a completely original tract was discovered, it was partly flooded and extended hundreds of meters.

This new section of the tunnel has allowed us to rediscover the original shape of this structure which had been lost in other sections. The structure is quite simple, sometimes there is a large channel with minimum water flow in the base with walkable sidewalks. In other areas there are large stone walls along the side that do not appear to have been placed there to support the structure

We wanted to find those sounds found in prehistoric and protohistoric ancient temples, using the partly flooded original structure of the tunnel. The purpose of this research was to determine whether the morphology of the tunnel was a random excavation typical of a mine and therefore free from special acoustic phenomena such as resonance or their design was for another purpose such for ceremonies as found in Great Britain and Ireland.



Figure 2. The entrance to the new section of tunnel was discovered in December 2010. We recorded the correct positioning of the singer after each performance, using the computer to test.

#### IV. MATERIALS AND METHODS

Being a preliminary study we choose to not slavishly examine every part of the new section of tunnel with electronic sound generators. Instead we wanted to recreate the conditions present in ancient times where one male or female voice was singing or praying.

After nearly twenty years, our recording equipment and microphones were far more dynamic and high-end compared to the equipment used by PEAR group of Princeton. We used a dynamic high-end microphone extended in the ultrasound field with a maximum sampling rate of 96.000Hz (Marantz PMD661 and Zoom H4N equipment).

To accurately incorporate the possible resonance response of the tunnels, ultrasensitive omnidirectional microphones used by sea biologists (Aquarian H2a-XLR Hydrophone, frequency response from 10Hz to 100.000Hz) were introduced into water which sits on the bottom of the new section of tunnels.

This type of microphone has a wide bandwidth normally used by sea biologists 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 the resonance vibration of the tunnel up to many meters away.

At the same time, to verify the correlation between the vibrations of the voice of the singers and the response of the tunnel we wanted to record the voices of singers. We used microphones with a wide dynamic range, but also with a flat response at different frequencies (Sennheiser MKH 800 Twin capacitor, response Frequency 10Hz - 50.000Hz).

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.

We analyzed the correlation between the sound source and response of the tunnel through sound spectrum graphics.

The singers performed a repertoire of ancient chant and overtone singing. The latter excited the surrounding structures with fixed unmodulated frequencies, typical of various mystical songs.



Figure 3. One of the digital recorders used (Marantz PMD661) and omnidirectional microphones which can be used under water (Hydrophones Aquarian H2a-XLR)

#### V. RESULTS AND CONCLUSIONS

Sound examination was immediately possible to verify a sound resonance response at very low frequencies, which lasted up to 20 seconds after the end of harmonic singing. The sound response of the tunnel was approximately 71,57 Hz, showing the shape of a wave similar to a Gaussian curve easily excited by the singers.

The experience lasted several hours and was always repeated at the right vocal strain, confirming the repeatability of the phenomenon on equal terms.

Although only preliminary, the examination carried out shows it would appear difficult to achieve a similar sound in a structure whose path is just random as is typical of a mine.

The duration of the phenomenon does not appear typical of an echo or a reverberation. Rather it is more typical of a resonance phenomenon evidently sought through a link between the structure and the human voice.

Further research is necessary using sound generators (electronic oscillators) that are able to resonate with the exact structure. An operation that we hope to undertake in the coming months.

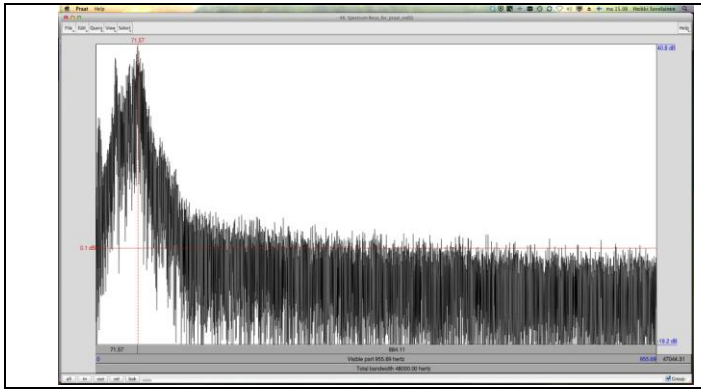


Figure 4. The sound response graphic taken during the experiment. It is easy to see a peak around 71,57Hz of 40db (visible part image until 955Hz of a total bandwidth of 48.000Hz) (by Heikki A. Savolainen)

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#### REFERENCES

- [1] J. Mortenson: "The Fall and Rise of Resonance Science", Proceedings of Materials Science & Technology, 2010, pp. 2864 - 2875.
- [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. Ibison: "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] SB Research Group: "Experiments on resonance phenomenon in Ravne's tunnels" SBRG page on YouTube, 2012 [http://www.youtube.com/watch?v=V2jJi\\_5L2Yw&feature=channel&list=UL](http://www.youtube.com/watch?v=V2jJi_5L2Yw&feature=channel&list=UL)