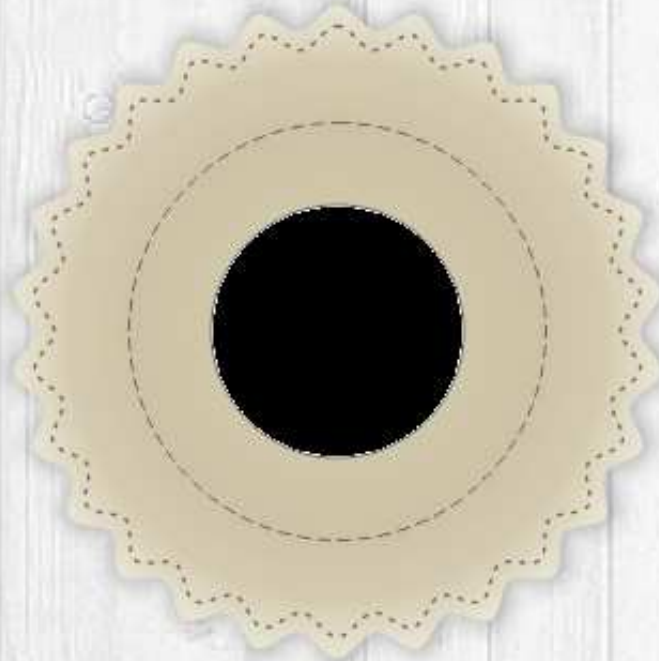




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Table of Contents

Psychology

- Facial impressions caused by shapes of faces and eyeglasses 10
Yasuto Okamura, Mitsuhiro Ura
- Behavioral Patterns among the Business Psychology Students..... 13
Tatjana Seibt, Michael Hager

Past, Nowadays and Future

- Informal Urban Development – Case of Albania 19
Ogri Mane

Social services

- Children with grapho-motor problems, their functioning and therapy..... 21
Jacek Szmałec

Law

- The term Justice in the Bulgarian legislation and the case-law of courts 28
Maria Radeva
- THE ALTERNATIVE METHODS OF CONFLICT RESOLUTION: SOME IMPROVEMENT CHALLENGES FOR JUSTICE IN COLOMBIA 32
Jorge Eduardo Vásquez Santamaría, Martha Eugenia Lezcano Miranda

Social Sciences - Past, Nowadays and Future

- PARTNERSHIPS AND THE ACTIVATION OF PARTICIPATION 38
Helena Neves Almeida
- Forward accountability in social work of the post-communist society 43
Vaike Raudava
- Digital social network and legitimacy (The relevance of social visibility of scientific publications in the digital world)..... 47
Sandro Serpa, Carlos Miguel Ferreira

Finance

- Classification and Measurement of Financial Assets as per IFRS 9 – Evidence from a Bulgarian Bank 52
A. Filipova-Slancheva
- The effects of maturity differences on bond yield related market segmentation 57
Borbála Szűle

Economy and Business - Past, Nowadays and Future

- Initial assessment of the impact of training on Algarve companies 60
Mafalda Sales-Gomes, Joana Serpa dos Santos, Fiona Vicente

Management

- The optimal utilization of employees' competences by understanding emotional components (A tacit knowledge-based approach)..... 66
Eszter Marczell-Szilágyi

Marketing strategy

- Study on Albanian consumers' attitude towards products with low level of pesticide 72
Silvana Dervishi

Planning

- Bayesian networks: definition of relationship between port variables to planning and management in a sustainability way 75
Beatriz Molina Serrano, Nicoletta González-Cancelas, Francisco Soler-Flores
- Contemporary landscapes: A case study of Rabaçal Castle – Penela – Portugal 82
Rute Sousa Matos, Paula Maria da Silva Simões

HRM

- Managing and rewarding the estimated performance 87
Mimoza Luta

Life long learning and distance learning

- Elements students value in online courses 90
Anssi Mattila, Minna Mattila
- Dashboards and OLAP services in LLL and distance learning processes (or experiences about log-based learning- and education-management) 94
László Pitlik, Anikó Balogh, Ferenc Szani, Máté Schnellbach

History and Archaeology

- The Orineti palace in Aversa: The architectural drawing and the relief of the structures (Representation and history of the residential fabric.) 103
Gaetano Andreozzi
- Archaeoacoustic Analysis in Enclosure D at Göbekli Tepe in South Anatolia, Turkey 107
Paolo Debertolis, Daniele Gullà, Heikki Savolainen

Languages and Literature

- Teaching English Literature in English as a Foreign Language (EFL) Classrooms 115
Noelia Malla García

Humanities - Past, Nowadays and Future

- Correlation between Behavioral and Clinical Factors for Tooth Decay in Children with Pyelonephritis 121
Sirma Angelova, Teodora Targova-Dimitrova, Dobrinka Damyanova, Dimitrichka Bliznakova

Archaeoacoustic Analysis in Enclosure D at Göbekli Tepe in South Anatolia, Turkey

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Abstract—We made an archaeoacoustic exploration at Enclosure D in the Göbekli Tepe archeological site. This site is the most ancient archaeological location recognized by archaeologists all over the world. It was dated 7,000 years before the Egyptian pyramids. Thanks to the site's discoverer we had the possibility to record the vibrations coming from the subsoil, magnetic fields and the sound produced by hitting with hand on central pillar n.18. The results are amazing and confirm that Göbekli Tepe has the same archaeoacoustic aspects of many other typical sacred sites we have studied in Europe and Minor Asia. However the most interesting finding was understanding that the pillar we examined is probably at the centre of a sophisticated mechanism of vibrations and magnetic fields affecting the brain. This discovery is in contrast with our knowledge of the level of technology produced by the civilization who built these sacred temples. Our results have to be considered as preliminary results, however due to the death of the person who discovered the site and the current geopolitical situation in Turkey we cannot continue the research. We hope other researchers will be able to confirm our results in future.

Keywords— *archaeoacoustics, Göbekli Tepe, low frequency sound*

I. INTRODUCTION

Archaeoacoustics is the right methodology to analyse archaeological sites which sometimes have interesting sound characteristics [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,23]. Although the term “archaeoacoustics” does not simply mean the study of sound in archaeological contexts, it also concerns all physical phenomena existing in those locations. It may also help to explain why ancient structures were built or carved into rock. Natural sound phenomena were used in several civilizations to create impressive rites, with some ancient structures modeled in a certain way to directly influence the mind through the vibrations they produced towards a particular state of consciousness [5,9,10,15,16,18].

In previous research, SBRG¹ demonstrated the existence of a relationship between mechanical vibrations from resonance phenomenon at some Neolithic temples and brain activity [5,6,9,10,11,12,14,15,16,17,18,19]. This point of view, with

¹ SBRG (Super Brain Research Group) is an international and interdisciplinary recognized non-profit association of researchers from Italy, Finland, U.K., Serbia and Macedonia researching on archaeoacoustic and anthropological properties of ancient sites and temples throughout Europe and Asia (www.sbresearchgroup.eu).

regards to ancient sites, has had more expansion in the nineties and our research group has followed this road since 2010, investigating and publishing our conclusions [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,23] on a large group of “sacred” sites in Europe and Asia (England, Bosnia, Serbia, Slovenia, Macedonia, Italy, Portugal, Malta, Turkey and Greece). Using modern digital recording techniques it is now possible to record non-audible sound frequency bands very clearly. These non-audible bands, such as ultrasound or infrasound, are able to modify brain activity. It is also possible to make them visible and display the magnetic fields affecting the mind; to do so we used UV Imaging, photography and special software to show the micro-movement of air crossed by magnetic forces [14,15,16]. We discovered that the majority of sites from Sogmatar in South-East Turkey [14] to Xaghra Stone Circle in Gozo (Malta) [18], from Alatri Acropolis in Italy [10] to Felix Romuliana Palace in Serbia [11] and Epidauros in Greece [18] are all placed over sources of natural low frequencies or magnetic fields which affect the human body and brain activity. Following the previous example by other authors of some sacred sites in the UK and Ireland (Robert Jahn with PEAR research group from Princeton, USA and Cook and Pajot from UCLA, USA) [1,20], we also studied the band of vibrations interfering with the human mind in various ways [5]. Sometime these bands of sounds have a direct effect on the human body without a person being aware of the associated mechanical vibrations, especially infrasounds. So after the analysis of about forty ancient sites from 2010 to 2017 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 fields that make these sites somewhat more mystical than others.

Any severe and artificial extreme sound imposed on the sonic environment has a profoundly destabilizing effect on people [3,22]. However, natural low vibrations with an absence of high pressure can have a strong influence on human health and some people can perceive very low-frequency sounds as a sensation rather than a sound [3]. Infrasound may also cause feelings of awe or fear in humans and given it is not consciously perceived, it may make people feel that strange or supernatural events are taking place [22]. So it is possible to hypothesize that, where a lot of natural low vibrations are present, ancient populations considered these sites to be “sacred” [3]. Through archaeoacoustic analysis, it is possible

to demonstrate that there was some knowledge of acoustic phenomena in the past, which could for example have been used in ancient rituals [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,23]. So this time we studied the Göbekli Tepe site using an archaeoacoustic approach to understand why the artificial hill was built just in this location. We applied the same approach we also used in Sogmatar, another sacred site in the area of Sanliurfa [14]. We were very interested to analyse this site because this is the most ancient archaeological site in the world, built 7,000 years before the Egyptian pyramids. In the agreement with the site's discoverer we were limited to only one enclosure of the ancient temples (Enclosure D) and to the baths placed at the entrance of the temples, but despite the limits the results were really striking. We hope that future researchers will further explore these particular aspects and confirm our discovers.

II. GÖBEKLI TEPE

Göbekli Tepe, located in South-East Anatolia 15km north east of the Turkish city of Sanliurfa, historically known as Edessa, is the most ancient archaeological site recognized in the world. It is an artificial mound dating from the Pre-Pottery Neolithic era (Fig.1). It was not a settlement or a village, but it consists of several sanctuaries in the form of round megalithic enclosures visible from a long distance away. Its enormous deposit of layers, up to fifteen meters high, have accumulated over several millennia covering an area of about nine hectares (Klauss). During the excavations, carried out since 1995 by the German Archaeological Institute in cooperation with the Archaeological Museum in Sanliurfa, no residential buildings have been discovered. However, at least two phases of monumental religious architecture have been uncovered. Of these, the older layer is the most impressive. One of the main features are the T-shaped monolithic pillars, each weighing several tons. They were erected to form large circular enclosures, at the center of which a pair of these pillars towers above the rest. The diameters of the circles are between 10 and 20 meters, and the 10 to 12 pillars of the circle are connected by walls of quarry stone. The enclosures have been designated the names A, B, C and D according to the date of their discovery in the first years of the excavations (Fig. 2). The age of layer III and the monumental enclosures are impressive: they can be dated to the 10th millennium BC, a time when people all over the world were still living as hunter-gatherers, except in the region of the Fertile Crescent in the Near East. Here people had started to settle in permanent villages and begin activities which led to the domestication of plants and animals. There is no question that the site of Göbekli Tepe was not a mundane settlement of the period, but a site belonging to the religious sphere, a sacred area, since the excavation has revealed no residential buildings. Göbekli Tepe seems to have been a regional centre where communities met to engage in complex rites. The younger layer of Göbekli Tepe has been dated back to the 9th millennium BC [24,25,26,27].



Figure 1. The entrance of Göbekli Tepe archaeological site. The enclosures are on the right of the image.

We have to be very grateful to the discoverer of the site, Klaus Schmidt, with whom we had an agreement for this research. We had the possibility to explore the sound coming from underground in Enclosure D near pillar n.18 (Fig. 3) which is close to a limestone floor. We also had the possibility to analyse that pillar from an archaeoacoustic point of view.



Figure 2. Enclosure D of the most ancient area in Gobekli Tepe is in the center of the map.

Enclosure D was discovered in 2001. It is particularly well preserved and its pillars are adorned with numerous reliefs of animals. We can see bulls, foxes, boars, gazelles, snakes, spiders and scorpions. The central pillars of Enclosure D (no.18 and 31) are 5,50 m tall and stand on a platform carved from the limestone bedrock (Fig. 3). Arms and hands are clearly visible on these central pillars. Pillar no. 18 appears to be carrying a fox in its right elbow. Both pillars depict beings

wearing belts and a fox fur loincloth (description by Institutum Archaeologicum Germanicum).

III. MATERIALS AND METHODS

For recording sounds we used a digital portable recorder with a maximum sampling rate of 192KHz (Tascam DR-680 of TEAC Group). At the same time for the recording 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. We placed the microphones over the floor close to the surface and in proximity of pillar no.18 (Fig. 4). However it was not possible to value the resonance of the structure because in the last few years it has been covered by a wooden roof to protect the artifacts from the rain. The presence of the roof removed any possibility to use ancient musical instruments in the air as we had done in other sacred sites in Europe and Asia (Fig. 5).



Figure 3. The central pillar no.18 from the side.



Figure 4. We placed the microphones close to the limestone floor near the base of pillar n.18, directed towards the floor.



Figure 5. The wooden roof for protecting the artifacts.

Before recording we used a spectrum analyser Spectran NF-3010 (Fig. 6) from the German factory Aaronia AG, to search for electromagnetic phenomena present around us which could have had a negative influence on our results. 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 various recorded audio tracks in real time.



Figure 6. Spectran NF-3010 from the German factory Aaronia AG.

To make the shape of the magnetic field visible, we used UV photography and a vector program for PCs (PIV – Particle Image Velocimetry). 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. 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 some characteristics necessary for scientific use. 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 analysing the UVA band (400-315nm) where it is possible to perceive the movement and the behavior of dust suspended in the air, and gas flows as steam shaped as a dipole in the magnetic field [14].

Particle Image Velocimetry (PIV) by Dantec Dynamics from Denmark is the software used to analyse this movement using UV video and photographs. 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 how PIV works is very simple: two consecutive shots illuminate a slice or volume of a flow field with particles suspended in the flow^[14]. 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 to calculate 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 and are presented to the user in an easy to understand and visual manner. The presentation is aided by advanced software post-processing. Dantec Dynamics is the leading provider of laser optical measurement systems

and sensors for fluid flow characterization and material testing (Fig. 7).

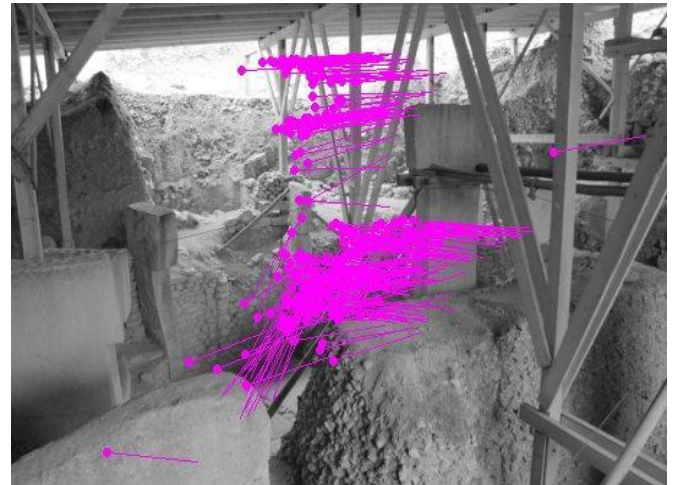


Figure 7. An interesting spiral magnetic field was found in the center of Enclosure D by UV Imaging (UV camera and PIV software).

IV. RESULTS

We found a constant very low frequency at 20-22Hz (on the border of audible sound) at 42 to 46 db (Fig. 8) of volume. Sometimes a peak of infrasound appeared around 14Hz swinging this constant frequency to 27Hz (Fig. 9). We took 12 recordings in that site: eight in Enclosure D, two outside the site in the empty baths at the entrance and two on the walkway (Fig. 10 and 11). These vibrations were not present at other locations other than the original site.

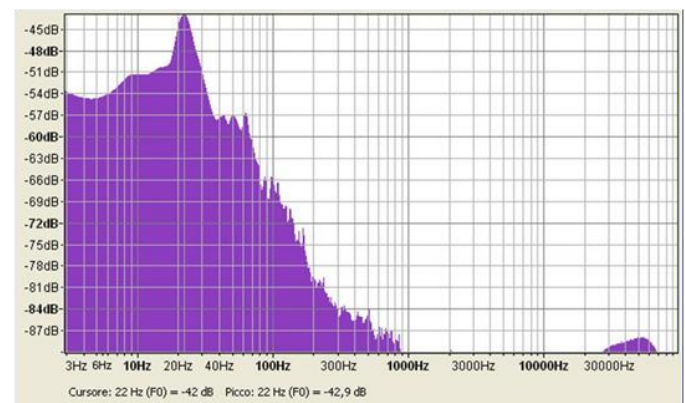


Figure 8. The plot of the sound coming from underground in Enclosure D. There is an important peak at 22Hz at almost 43db of volume.

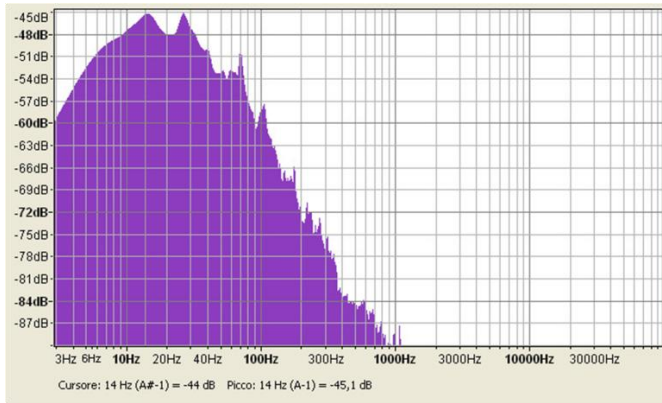


Figure 9. The plot of the sound when a peak of infrasound appeared around 14Hz swinging this constant frequency to 27Hz.



Figure 10. The entrance of the archaeological site.

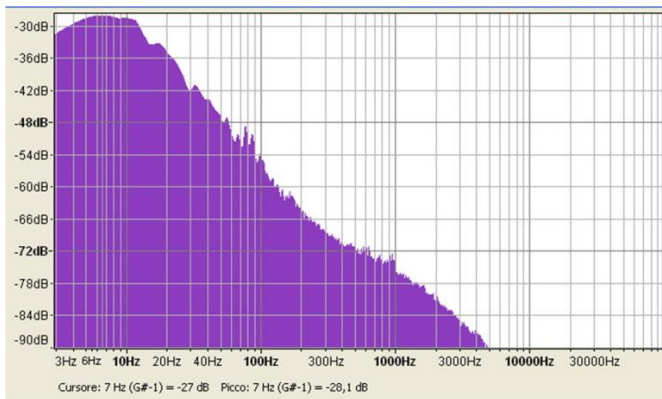


Figure 11. The plot of the sound at the entrance. There are no audible vibrations as found in Enclosure D.

We also took some recordings along the road to the archaeological site (Fig. 12), but we did not register any audible vibrations as found in Enclosure D so we can conclude that those audible vibrations are present only in the enclosures.



Figure 12. The road to the archaeological site.

Using UV photography and a vector program for PCs (PIV – Particle Image Velocimetry) Enclosure D showed an interesting spiral magnetic field placed in the centre of the area (Fig. 13) close to pillar n.18. It appears to be always detectable even from different perspectives (compare figure 7 to figure 13), but with a continual movement which changes the aspect of the shape.



Figure 13. The different aspects of the spiral magnetic field located on the side of pillar n.18 respect the findings shown in figure 7. It always appears present even from different photograph perspectives.

The correct localization of this spiral magnetic field is particularly evident with an analysis based on the study of the vectors of steam water molecules movements. It places the centre of the magnetic field just on the side of pillar n.18 (Fig. 14 and 15).

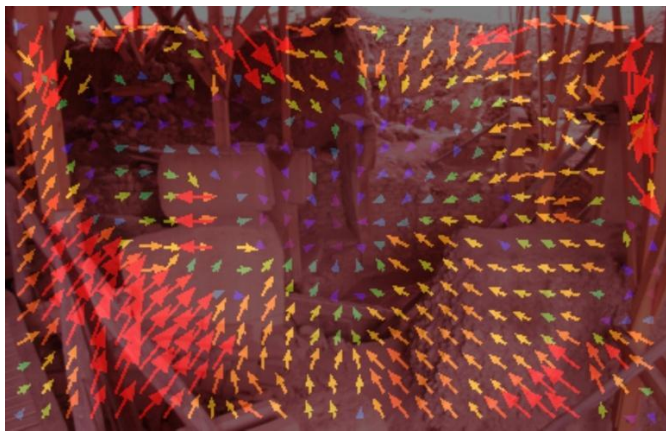


Figure 14. The direction of the vectors of steam water molecules movements

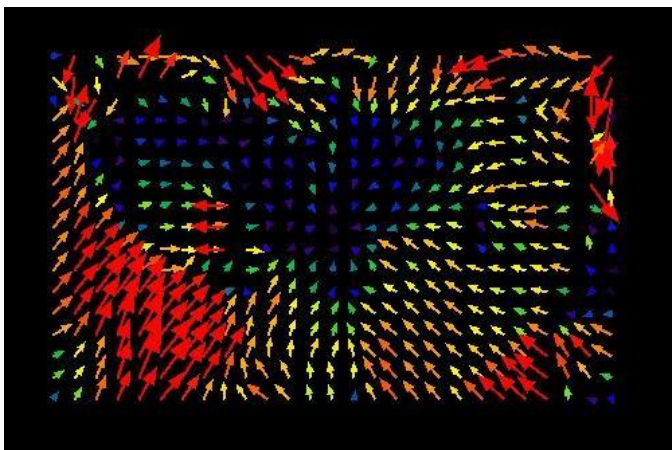


Figure 15. The curious appearance of the vectors showing a spiral movement of the magnetic field found in the centre of Enclosure D. The different colours are due to the different speeds of molecules: from indigo (slower) to yellow (faster).

We also discovered an interesting resonance phenomenon that can be elicited by delicately striking a hand on the central megalithic pillar n. 18, as visible in figure 16.



Figure 16. The maneuver to stimulate resonance of the pillar n.18 by a delicate tap of the fist.

This maneuver generates a very interesting resonance frequency as powerful as a drum. The main resonance

frequency looks to be around 68-69Hz with harmonics of 91 Hz and 138 Hz (Fig.17).

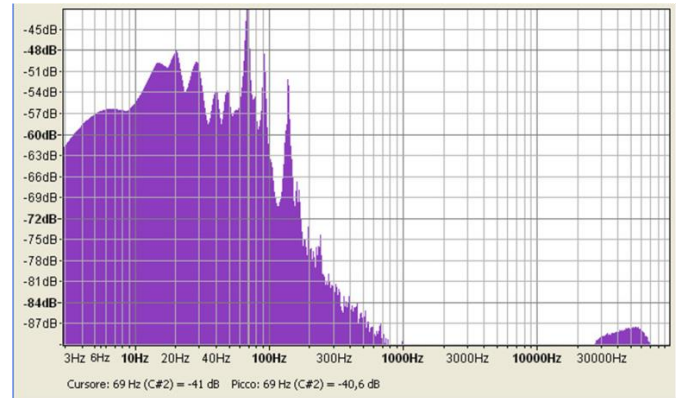


Figure 17. The plot of pillar resonance. There is a tap sound of 69Hz and its harmonics. It is visible from the peaks of infrasound previously described.

It is interesting that the resonance base sound and its harmonics are all in the range of 65-145Hz, which we described previously as affecting brain activity and potentially helping to make ancient rituals more impressive sound wise [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,23]. In other archaeological sacred sites we have used many different methods to investigate this resonance area. However in this Turkey study we were limited by time, personnel and equipment and we did not have the possibility to test the site from all points of view.

The analysis of the sound spectrum and listening audio files led us to understand the megalith must be hollow due to the behaviour of sound waves. We present that the pillar itself is hollow and the lineup of pillars might have some compiled frequency function. The audio frequency echo response from the "tap" is clearly caused from the pillar itself, not from the limestone floor. (Fig. 18 and 19).

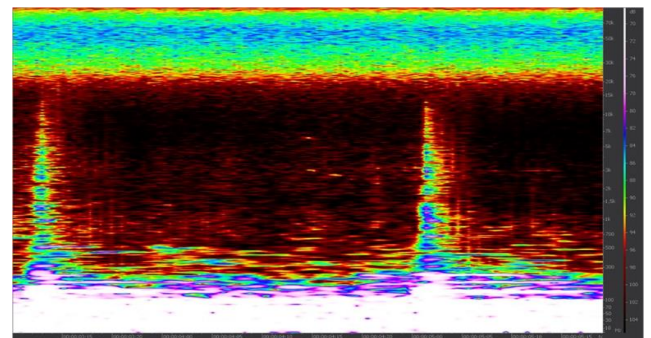


Figure 18. The enhanced (2,5s) spectrogram of the delicate tap of the fist on pillar n.18. The peaks are taps and vertical higher frequency echoes are clearly visible and represent reflection of sound waves in the pillar cavity. (RX4 adv. image).

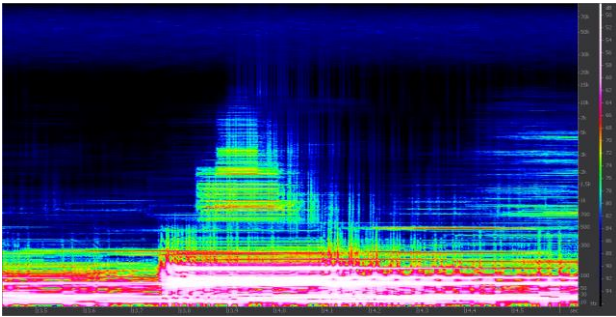


Figure 19. The zoomed (1s) spectrogram of the tap audio shows a cavity resonance in pillar n.18. Also the infrasounds are clearly visible. (RX4 adv. image).

V. DISCUSSION

There is no doubt that also in this short study this archaeological site looks to be full of surprises. As there are no known underground water streams below the artificial mound, it is possible to suppose that the recorded low frequencies are caused by tectonic movement (frictions) of geological faults passing through this area.

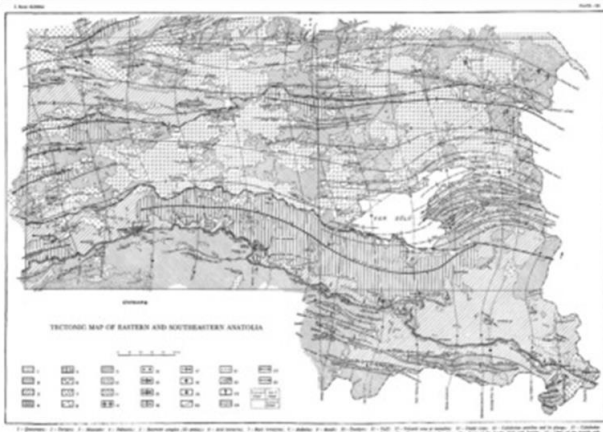


Figure 20. Tectonic map of East and South-East Anatolia (Technical University of Istanbul) [21].

This is particularly evident for the readings taken at the ancient purification baths placed at the entrance of the archaeological site (Fig. 21).

In this location the frequency is not at 20-22Hz, so we can suppose that it is in connection with the magnetic fields we discovered in Enclosure D. Nevertheless we cannot say if it is induced by the positions of the pillars or if it was in that location before the temple was built. Either way, following our previous experience we can be sure that it has an effect on the brain activity for a person present at that site. The vibrations we found at Enclosure D are not strange when viewed within a panorama of other sacred sites across Europe and Asia.

In the baths and Enclosure D we also found infrasound resonances around 14Hz which we can consider typical for a sacred site [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,23], because these frequencies affects the mind by creating the sense of relaxation and facilitates prayers and meditation. We have also found these frequencies in other sacred sites, notably only in sites, but not in the surrounding areas.



Figure 21. One of purification baths placed at the entrance of the site where we took some readings.

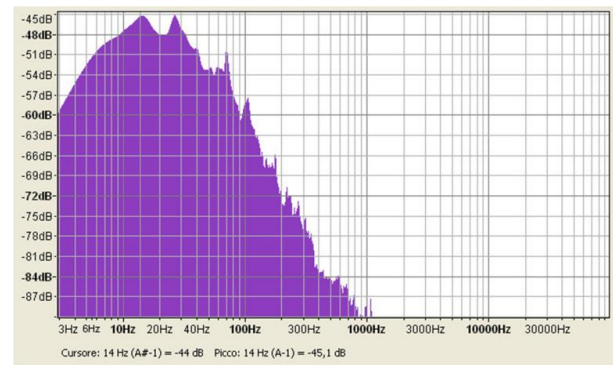


Figure 22. The plot of results taken in the purification baths. A double peak at 14 and 27Hz is particularly evident.

Two of the most famous ancient sites in the world we have studied have similar characteristics, for example Xaghra Stone Circle in Gozo (Malta) and Epidauros in Greece [18].

Similarly Epidauros [16] and Lasko, North Slovenia, both have ancient Roman baths sunk into the ground. We have to consider that underwater vibrations have the best means of transmission to the human body. Under these conditions vibrations are able to penetrate the body without passing through the acoustic organ [15]. In Epidauros the area containing the bath complex is generally identified as the “Akoai”, mentioned by the ancient traveler Pausanias. The building is connected with the fountains on its southern side. The water comes from the springs of Mount Kynortion. The bath building occupies an area of approximately 650 mq2 and consists of four parallel wings. Now the source of sacred water is non-existent, but the baths are still present. With the same equipment used in Göbekli Tepe we recorded an interesting peak of frequency around 23-25Hz at -45db similar to Xaghra Circle in Gozo (Malta) but certainly less powerful than in Malta. The diminished strength was because we recorded in the air and not in an expired water source. In Göbekli Tepe we do not know from which water source the water was coming, but we can suppose it fitted a similar purpose.

The resonance we found in Enclosure D by striking the pillar n.18 was amazing. We can assume that there is an equivalent version of a musical box below the pillars and the pillar works as a transducer for the resonances, but the current data is insufficient for a definitive statement. We have to consider it only a starting point for future research.

VI. CONCLUSION

These results have to be considered preliminary, but our well tested methodology which was used with success in other famous archaeological sites opens the way for new research in this direction at Göbekli Tepe.

Although the problem remains that we cannot pursue further research on this site because of the sudden death of the site's discoverer, Klaus Schmidt, and the change in direction of excavations closed the collaboration in this research. In particular the geopolitical situation in the southeastern Mediterranean area, wars and coups d'état, and their impacts on political choices for the archaeological field. make any future collaborations more difficult. Regarding Göbekli Tepe, we can only hope other local researches will carry on our archaeoacoustic research and confirm the results we have presented in this paper.

ACKNOWLEDGMENT

We are very grateful to the discoverer of the archaeological site, Klaus Schmidt, for his availability to open Enclosure D for our unconventional study, but we are very sad and dismayed for his sudden death which halted our research.

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