MUSICAL PILLARS AND SINGING ROCKS

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The ancient Hindu temples are well known for their grand architecture and construction. Almost all of the temples have beautiful and majestic sculptures carved on their interior and exterior walls and pillars. Sacred deities such as various forms of God and Goddess, mythical figures such as *vyalas*, horses, elephants, dancing damsels and musicians playing their instruments are some of the prominent sculptures carved on temple pillars. It is also interesting to note that some of the pillars, which are constructed as simple circular columns with and without any carvings produce melodic tones when tapped on them with fingers. Several temples such as Vijaya Vitthala temple (15^{th} century) in Hampi, Karnataka, Madurai Meenakshi temple (16^{th} century), Nellaiyappar temple (8^{th} century) in Tirunelveli and Suchindram Thanumalayan temple (17^{th} century) in Tamilnadu have these musical pillars. These pillars are not hollow and both ends fixed. Thus these musical pillars indicate the acoustical knowledge of Hindu temple architects. It is known that in Hinduism music and dance are regarded as means of worship of Gods and Goddesses. The musical pillars contribute to the acoustical characteristics of worship spaces. These musical pillars are man made structures. However in nature, there are rocks that have the property of sounding like a bell when struck or rubbing them which are called Singing or ringing rocks. Examples of these natural singing rocks are found at Upper Black Eddy and Lower Pottsgrove Township (Pennsylvania, United States), Western Australia, Cumbria (England), Montana (United States), Querétaro (Mexico), Tiree (Scotland). The musical instruments which are made with rock or pieces of rock which are struck to produce musical notes called Lithophone. This paper presents a review of the acoustical studies of these pillars and rocks.

1. Introduction

Some ancient south Indian Hindu temples built between the 8^{th} century and the 16^{th} century have in them interesting architectural elements known as musical pillars which are made of solid granite. The columns of these musical pillars are often carved from a single piece of granite stone, and they are tuned by means of their length, diameter, and the type of attachment with ceiling and floor. It is said that these musical pillars were played to accompany devotional chants, vocal music and dance performances [1]. Acoustical and architectural significance of non-western worship spaces were studied by Calamia et al [2]. Kameswaran and his research team studied the acoustical aspects of musical pillars in Meenakshi Amman temple, Madurai, Tamil Nadu [3]. Kumar et al [4] carried out the non-destructive characterization of musical pillars of mahamandapam of Vitthala Temple at Hampi, Karnataka. Patil et al [5] measured the resonant frequencies of musical pillars in same temple. In this paper we present an overview of musical pillars at various south Indian temples and analysis of acoustical measurements carried out at Vitthala temple, in Hampi. The measured sound spectrum is compared with previous literature data and it is observed that the measured data is agreeing well with literature. The study also extended for sound spectrum analysis of musical pillars in Elephant Temple, near Chennai, TN. Analysis of musical pillars in Elephant temple, Chennai is carried out using the YouTube [6] data. Singing rocks are rocks that sound like a bell when struck with smaller rock or mallet. The singing rocks are commonly found at the following places; *Ringing Rocks Park, Upper Black Eddy, Lower Pottsgrove Township, Pennsylvania*, United

States, *Bell Rock Range - Western Australia*, Australia, *Musical Stones of Skiddaw - Cumbria*, England, *Ringing Rocks*, Montana, United States, *The Hill of the Bells (Cerro de lasCampanas) - Querétaro*, Mexico, *The Ringing Stone - Tiree*, Scotland. Singing rocks are also known as sonorous rocks or lithophonic rocks [10].

2. Survey of musical pillars in south Indian temples

These fascinating musical pillars are found in this following temples: Alakarkovil, Alvarthirunagari, Shenpakanallur, Kalakadu, Kuttralam, Suchindram, Shenbagaram Nallur, Thadikombu, Tirunelveli, Thirumayam, Tenkasi, Madurai, Chennai, Kanchipuram, Dindigul (all are in Tamil Nadu), Lepakshi, Tadpatri, Tirupathi, Visakhapatnam (all are in Andhra Pradesh), Thiruvananthapuram (Kerala) and Banglore Ramarajanpeattai, The Pampapati, Chowdeshwari and Vitthala shrines at Hampi (all are in Karnataka). Example of musical pillars in various south Indian Hindu temples and plan view of musical pillar in Vitthala temple, Hampi are shown in Fig.1 and 2.

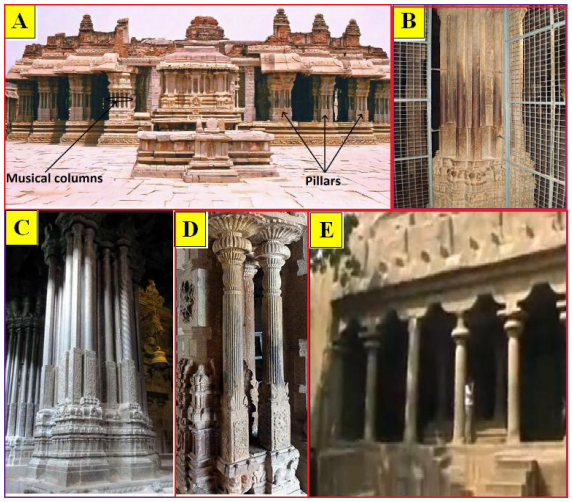

Figure 1. Musical pillars in various Hindu temples. (A: Vitthala Temple, Hampi, Karnataka; B: Meenakshi Amman temple, Madurai, Tamil Nadu; C: Nellaiyappar Temple, Thirunelveli, Tamil Nadu; D: Vishnu temple, Thirumayam, Tamil Nadu; E: Elephant temple near Chennai, Tamil Nadu)

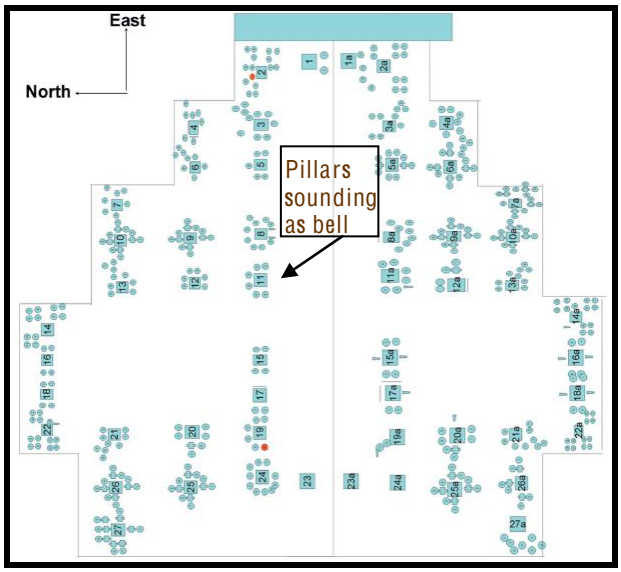

Figure 2. Plan view of the musical pillars in Mahamandapam of Vitthala temple, Hampi [4].

There are two type of musical pillars found in these temples. They are called (1) *Beating* or *tapping pillars* and (2) *Blowing pillars* [7]. The tapping pillars will produce different singing tones by tapping on them with fingers while the blowing pillars will generate a sound by blowing air in the holes like wind instruments. It is said that stones which emit a long, deep sound like that of a bell are known as *male stones*, the stones which have a long vibration like that of a brass vessel are called *female stones* and the stones that are crude and uneven, with little resonance, are called *neutral stones.* These types of stones are used to make musical pillars [8]. The sculptors select the rock (stone) to make these pillars by tapping them. Usually these pillars are three to seven feet long and are of circular cross sections. Some pillars are also of square, rectangular, octagon and polygonal cross sections. Most of these pillars are plain without any carvings but some of the pillars have carvings (Ex: Nelliayappar temple pillar have Squirrel carving [8]).

These musical pillars are generally classified into three types; *1. Shruti, 2. Gana* and *3. Laya*. The *Shruti pillars* when tapped with fingers would produce the basic notes of the *swaras (sa, ri, ga, ma, pa, dha, ni)* on the basis of which chants would be rendered. By tapping *Gana* type *pillars*

notes that make classical ragas like *Kharaharapriya* are produced. *Laya pillars* would produce a *taal* (beats) when tapped. Some musical pillars not only produce sounds but also cause adjacent pillars to vibrate in resonance to produce harmonics and create musical effects. In this case, each pillar is sculpted to create a different scale of sound. A unique feature of Nelliayappar temple in Thirunelveli, Tamil Nadu, is that the *Mani mandapam* located near the *Nandi Mandapam* with two giant pillars carved out of a single stone and each one is having 48 sub pillars which produce musical notes when struck. Similarly, there are two more musical pillars in *Devi sannidhi* of this temple. The shapes of the pillars here are circular, square and octagonal. These musical pillars in Nellaiyappar temple are a combination of the *Shruti, Gana, Laya* types.The Alvar Thirunagari temple in Tamil Nadu has both *tapping pillar* as well as blowing *pillar* in *Vasanta Mandapam* [7]. The blowing pillars have two holes in both sides of the column. When we blow through each hole different sounds are produced. Also if two people blow from both ends alternatively, the pillar produces sound like shankha (*conch-shell*) and ekkalam (*horn*) [7]. The blowing pillars are also seen in Shenbagarama Nallur Vishnu temple, Nanguneri, Tamil Nadu. These blowing pillars have a circular shape with conical bore in the center about foot long. They are about one inch in diameter in one side and slightly smaller hole in other side. When blowing through the bigger side of the hole, conch like sound produced while blowing the smaller hole produce ekkalam (a long pipe-like musical instrument) These pillars are located towards the South-West of Garba Graha [9].

In Thanumalayan temple in Suchindram, Tamil Nadu, the musical pillars are erected opposite to the *Bhairavar Mandapam*. In northern side, there is a small musical pillar located at the center, surrounded by 24 pillars and in southern side there is a small pillar located at the center and surrounded by 35 pillars. The shape of each pillar is octagonal at the top and square at the bottom [7]. The sounds produced by these pillars are similar to those found in the Nellaiyappar temple, Tirunelveli, Tamil Nadu. In Meenakshi Amman temple at Madurai, Tamil Nadu, there are five music pillars which are located near the north tower corridor. The temple near Kalakadu, Tamil Nadu has sixteen musical pillars [9]. In Sri Anantha Padmanabhaswami temple in Thiruvanthapuram, Kerala, there are four musical pillars which are tapping pillar type. The Simhachalam temple in Visakhapatnam, Andhra Pradesh also exhibit music from one of its pillars. There are three musical pillars in Soundara Valli Thayar temple of Tadikombu, near Dindigul, Tamil Nadu. Musical pillars also found near the *Kalyana mandapam* of the Venkateswara Temple, in Tiruapthi, Andhra Pradesh.

In Vithala temple in Hampi, Karnataka, there are cluster of 56 musical pillars located near the *mahamandapam*. These musical pillars are tapping pillar type. When tapped on them they produce sounds of various musical Instruments. The detailed and an excellent survey of musical pillars and associated musical instruments in Vitthala temple, Hampi, Karnataka, is given in a paper by Kumar et al [4]. There, some of the pillars will produce sounds of Saptaswara (seven notes) and following instruments such as Panchatala (five tones), Jaltarang (water instrument), Tabla, Veena, Mridanga, Ghatam, Damaru, Kerala Mridangam (all are percussion instruments), Ghanta (bell) and Shankha (conch-shell).

3. Singing rocks and lithophones

Some natural rocks not only sing but they can produce a clearly defined notes of particular frequencies. These singing rocks are found in many places throughout the world. A man made musical instrument consisting of these singing rock or pieces of rock are called lithophone. A rudimentary form of lithophone is called the "gong rock", which are natural rock formation opportunistically adapted to produce musical tones. The naturally formed “gong rocks” are seen at following places; Mfangano Island, in, Kenya. Luray Caverns, Virginia, United States, Tenkasi in South India, Ringing Rocks Park in Pennsylvania, United States is another well known lithophone. The comprehensive list of places, where these naturally formed singing rocks and lithophones found is given in references [10,11]. Figure 3 and 4 shows the naturally formed singing rock and man-made lithophone (*Note: click on the audio symbols to listen to the singing sound*). Wherry [12]

concluded that the ringing was due to the texture of the diabase rocks and that they were supported by other rocks. Faas [13] found that when the rocks were struck they created a series of tones at frequencies lower than the human ear can hear. An audible sound is only produced because these tones interact with each other. Although Faas's [13] experiments explained the nature of the tones, they did not identify the specific physical mechanism in the rock which made them. Some of the singing rocks and musical pillars found around the world are given in references [14-42].

Figure 3. Examples of naturally formed singing rocks.

Figure 4. Examples of man-made lithophone from piece of singing rocks.

4. Acoustical analysis of musical pillars at Vitthala Temple, Hampi

The Vitthala Temple at Hampi, Karnataka is one of the famous world heritage sites in south India. The Vitthala Temple stands on the southern bank of the Tungabhadra river in Karnataka. The temple architecture is based on Vijayanagara architecture and this temple is constructed in 15th Century AD [1, 4]. The Vitthala temple stands in a large rectangular enclosure (164 m X 94.5 m). The *Mahamandapam* of the temple is reported to contain 56 musical pillars, each 3.6 m high, 40 of which are regularly disposed to form an aisle [1, 4]. The remaining 16 form a rectangular court in the center. Musical pillars in this temple are made of solid granite stone and when tapped with fingers they produce many types of musical sounds. Two of the music columns in pillar number 11 (*refer Fig. 2)* is chosen for the acoustical analysis. The sound produced by tapping on the pillar is recorded with audio player. This particular pillar is chosen because they are famous for producing door bell sound like *'ding-dong'*. One of the columns in the pillar 11 would produce the sound *'ding'* and second one will produce *'dong'* sound. By tapping alternatively, we can produce both the sound like a doorbell in home. The recorded audio file is converted to .wav format and used as input for frequency analysis. LabView Sound and Vibration Suite is used for the FFT calculations.

Initially both the columns are tapped individually and their spectra are analyzed. The fundamental frequency of the column which produces '*ding*' sound is 646 Hz and the column that would produce the '*dong*' sound is 538 Hz. The sound spectra of these columns are shown in Fig. 5 and Fig. 6. Then, both the columns are tapped alternatively and FFT analysis are carried out. This produced the sound of frequency values of 646 Hz and 538 HZ. The time-domain plots of measured and YouTube data of these two doorbell columns are shown in Fig. 7 and Fig. 8. The measured frequencies of these columns are compared with literature data of Kumar et al [4] and Patil et al [5]. The results also compares well with the YouTube audio file of same columns. The sound spectra of the measured data for two of the musical columns in pillar 11(ref.Fig.2) stroked simultaneously is shown in Fig. 9. The measured frequencies of these door bell pillar columns are in good agreement with literature as well as YouTube data.

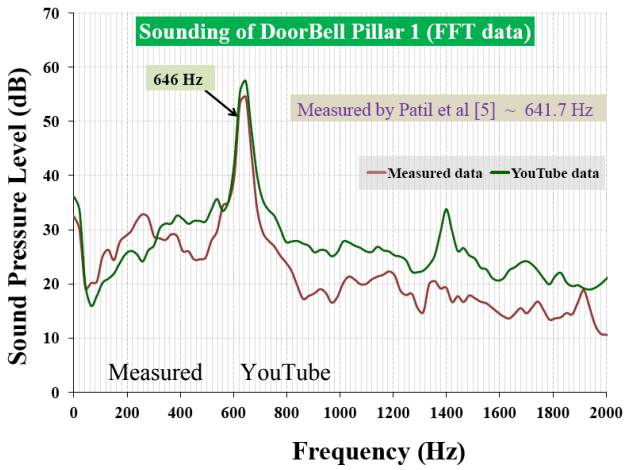

Figure 5. Sound spectra (FFT) of one of the musical columns in pillar 11 (*Refer Fig.2*) which is popularly known to produce the sound of a bell ('*ding*' sound).

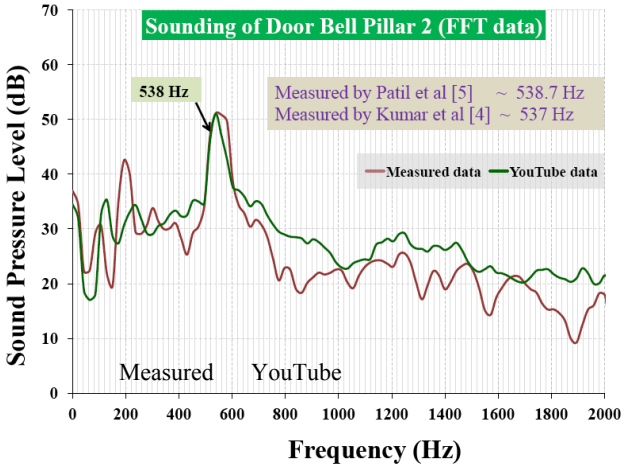

Figure 6. Sound spectra (FFT) of one of the musical columns in pillar 11 (*Refer Fig. 2)* which is popularly known to produce the sound of a bell ('*dong*' sound).

Sound spectral analysis is also carried out on another column which produces two sounds of different frequencies by tapping at two different places on the same pillar. The spectral plot of this particular type of column is shown in Fig. 10. The measured frequencies of this column are 495 Hz and 646 Hz.

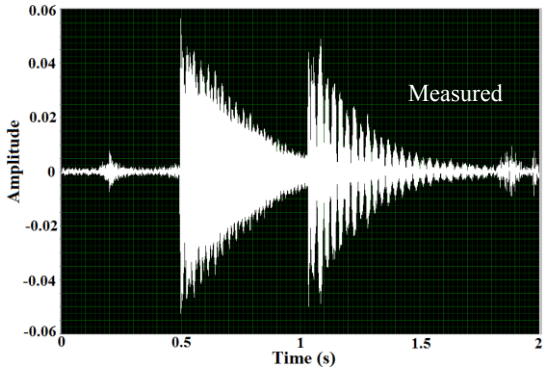

Figure 7. Measured time-domain data of two of the musical columns in pillar 11 (*Refer Fig. 2*) which is popularly known to produce the sound of a bell ('*ding-dong'* sound)

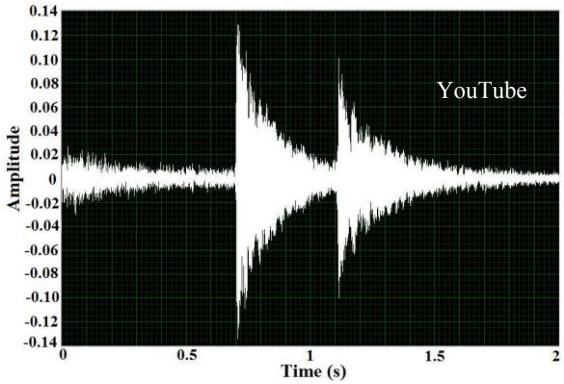

Figure 8. Time-domain data extracted from YouTube of two of the musical columns in pillar 11 (*Refer Fig. 2*) which is popularly known to produce the sound of a bell ('*ding-dong'* sound)

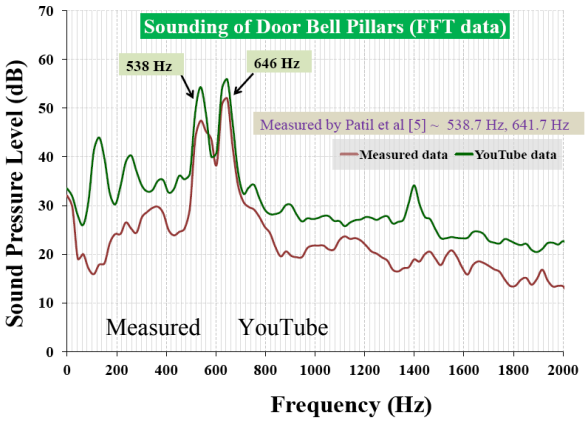

Figure 9. Sound spectra of two of the musical columns in pillar 11 (*Refer Fig. 2*) which is popularly known to produce the sound of a bell ('*ding-dong'* sound).

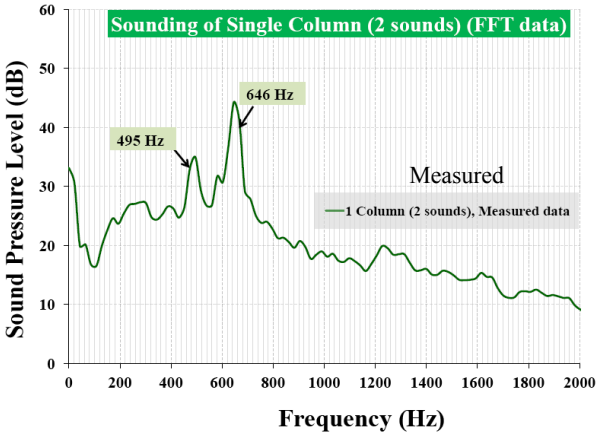

Figure 10. Sound spectrum (FFT) of one of the musical columns in Vitthala temple which would produce two sounds of different frequencies by tapping in two places on the same pillar.

5. Acoustical analysis of musical pillar at elephant temple, Chennai

Sound spectral analysis of the musical pillar at elephant temple, near Chennai, Tamil Nadu is also carried out. The column used for this study is shown in Fig. 1(E). The sound data extracted from YouTube [6] of this musical pillar is used for the FFT analysis. The time-domain and frequency domain plot of this particular pillar is shown in Fig. 11 and Fig. 12. It is observed that similar to the Vitthala temple column, these pillar also produced two different sounds by striking in two different places. The two observed sound frequencies are 129 Hz and 150 Hz.

6. Conclusions

The Hindu temples date back to ancient times and Hindu temple architecture has evolved greatly in the last 2000 years. Some of the Hindu temples in south India constructed during 8^{th} century and later period (15^{th}-17^{th} century) have interesting architectural elements called musical pillars. These pillars are not hollow and when tapped or blown through the hole they would produce various types of musical tones. Thus these musical pillars indicate the acoustical knowledge of

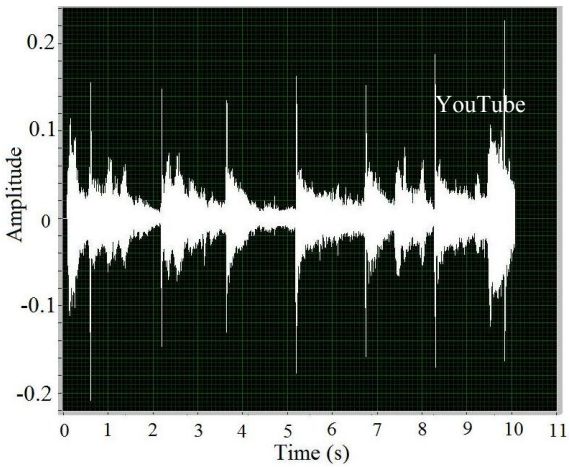

Figure 11. Time-domain data extracted from YouTube of musical pillar in elephant temple, near Chennai, Tamil Nadu.

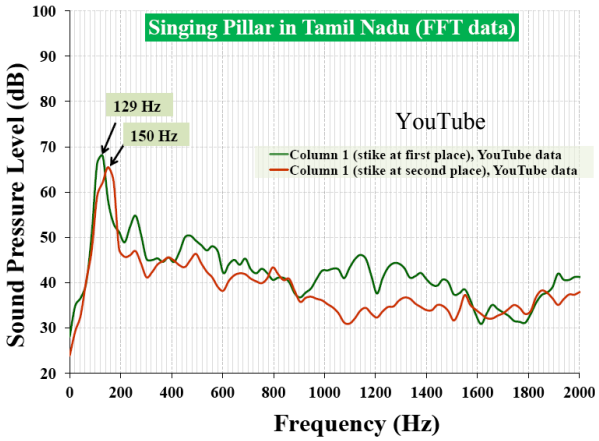

Figure 12. Sound spectrum (FFT) of musical pillar in elephant temple, near Chennai, Tamil Nadu.

ancient Hindu temple architects. These musical pillars contribute to the acoustical characteristics of temple worship spaces. In this paper an overview is presented on the acoustical studies carried out on these pillars. Also presented is the sound spectral analysis of the particular musical pillar which produce doorbell like sound and also of another pillar producing two distinct sounds when tapped at two points in Vitthala Temple at Hampi, Karnataka. The sound spectral analysis is also carried out on the musical pillars of elephant temple, Near Chennai, Tamil Nadu. It is observed that the frequency from the measured sound spectrum agrees well with the earlier reported literature data. It is also noted that even though musical pillars are available in many temples in south India, only limited studies are carried out to date to understand the acoustical and design aspects of these fascinating musical pillars. Although acoustical studies of tapping pillars seen in Vitthala temple have been reported in literature, there does not seem to be any acoustical studies reported on the musical pillars seen in Tamil Nadu temples. In nature, there are rocks that have the property of sounding like a bell when struck or rubbing them which are called singing rocks. Unlike the musical pillars which are man-made, these singing rocks are naturally formed. These rocks are identified as diabase rocks and the internal micro-structure of this structures are similar to the granite structure found in the musical pillars of South Indian temples. In this study, it is found that the singing rocks are fascinating, the sound generation mechanism is not well understood due to the limited studies.

Acknowledgement

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