

# Acoustic Excavations

## Soundings in the Ranigumpha Caves

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I am a sound recordist. Have been one for about 30 years now. A sound recordist with an interest in technology, who had been building equipment and microphones for use in his work and fiddling with computers (with an Apple II and then with the inevitable PCs). I was asked six years ago to measure the acoustics of an ancient archaeological site.<sup>1</sup>

<Problem one: what does one actually measure?>

I knew it had to include Reverberation Time (RT measured in Sabines), but what else? I was quite sure reverberation time would not tell me very much, and this was an outdoor space where there should be no such thing as reverberation time. I was not even very sure that the site would amount to very much. From childhood, I had been taken and shown pillars that were tuned to musical pitches, whispering halls, echo spaces and had learnt not to be impressed. But one had to try.

<What equipment would I be using?>

I knew acoustic measuring equipment was very expensive and I did not know where I could find any. In any event, even cheap sound cards had more dynamic range than expensive oscilloscopes and I had some faith in the power of well-written programmes using the resources of a personal computer. I had an unregistered shareware version of Cool Edit (version 1.3xx) so I created some files I hoped would be useful: a white noise burst, sine sweeps, and short bursts of pure sine waves at various frequencies.

A home-made mixer, an omni microphone, cables and 66 MHz 486 PC with a hard disk of about 540 Mb. Computer monitor, amplifier and speaker we would rent locally in Bhubaneswar. We hired a local electrician who jumpered the overhead electrical wires to power up the computer, and borrowed a bench from a nearby tea stall. We made quite a few measurements, with the mike in all the possible places I could think of, but ran out of hard disk space in one night. But one had heard the acoustics of this space, and one knew this was not enough. The place was immensely noisy with crowds, monkeys, tea stalls, temples and a heavily travelled highway, but after midnight the quiet was uncanny.

<The real odyssey began when I got home. What do you do with the measurements?>

I knew my measurements were crude, but good enough to support my saying the acoustics of this space were very good, and generally a genuine surprise. But what else? I remembered an old article in the *Wireless World* which spoke of computer modelling of yet-to-be-built theatres to simulate their sound, and I thought that might be a good way of studying such spaces. I knew Bose Corporation was an early pioneer of this modelling, but not much else.

It was also the beginning of Internet in India, so I started looking for acoustics, for acoustic modelling and any search phrase that looked possible. I learnt that acoustic modelling was coming of age, its predictions were becoming useful and also that at least one major programme could be downloaded as a demo.<sup>2</sup>

In June last year, five years after our first trips, I went back to Ranigumpha with a laptop with new software that would generate measurements instantaneously, and with a vague sense of disquiet. I wondered, "Did I imagine the sound of Ranighumpha – reconstructed and reinforced in memory – or did it really sound that good?"

One handclap standing on the stage, and it was all quite real.<sup>3</sup>

So now to what we are saying.



<A third-century BC theatre in India>

*Rani Gumpha* is the current local name given to the largest structure in a group of excavated caves called Khandagiri, very close to Orissa's state capital Bhubaneswar. The structure dates to about the 2<sup>nd</sup> or 3<sup>rd</sup> century BC, the period just after Ashoka.

In Indian archaeological terms, it is a very early site and represents an important transitional period in the country's history. A long period of Greek influence on the western side

of India had begun to ebb after Alexander's conquest and in the rise and decline of the Mauryas India had seen its first nation-wide empire.

It is an interesting site because it has no apparent religious function. It is very richly carved: an elaborate two-storey structure with evidence of a considerable amount of wood-work which decayed long ago.

In particular, there seems to have been a large wooden deck or platform extending in front of the first floor. And the flat space in front of the structure can accommodate a large audience.



<Could this have been a theatre? Or at least, some kind of a performance space?>

The suggestion has been put forward before, notably by Percy Brown, art historian, and Dhiren Dash, theatre activist from the region. But the general explanation, offered by the Archaeological Survey of India and others, has been that these were just another set of caves set apart for meditation.<sup>4</sup>

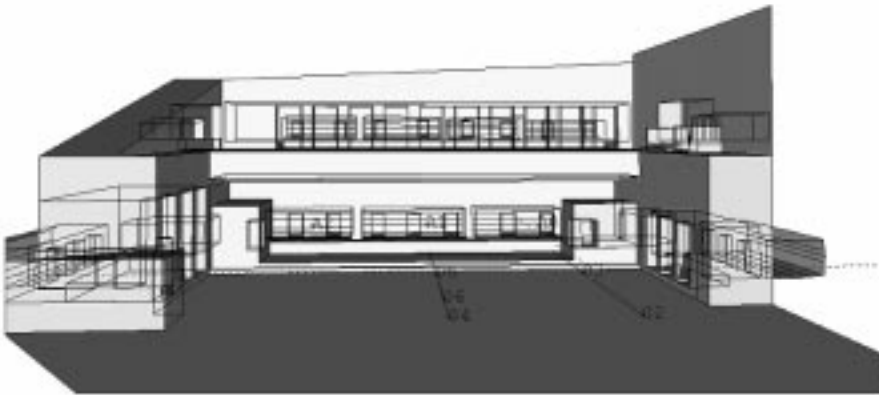
The elaborate carving in a series of friezes suggests a narrative of some sorts, but no one has yet tried to link the images to any of the known epics or ancient stories. There are images of dancers performing in front of a seated personage, who could be a king. The treatment of the space on which the dancer stands – and this decoration is repeated all along the frieze – suggests the kind of wooden platform that extended in front and was dense and heavy, built up from many thick-hewn logs.

The structure is also very complex, with many small spaces connected with narrow openings, which seem to have no real function; as well as curved floors and rear walls.

Most remarkable of all are the acoustics of this space. It does not have the kind of unusual acoustics frequently associated with archaeological sites, no odd echos, no whis-

pering spaces. But if you stand and speak anywhere in the performance area, you can be heard all along the audience space. A much louder sound than you would expect, very clear and detailed, with just enough hint of reverberation to provide body to the sound. Certainly not the kind of sound you would expect in an outdoor space. Remarkably, this effect disappears just a foot or two away from the performance space.<sup>5</sup>

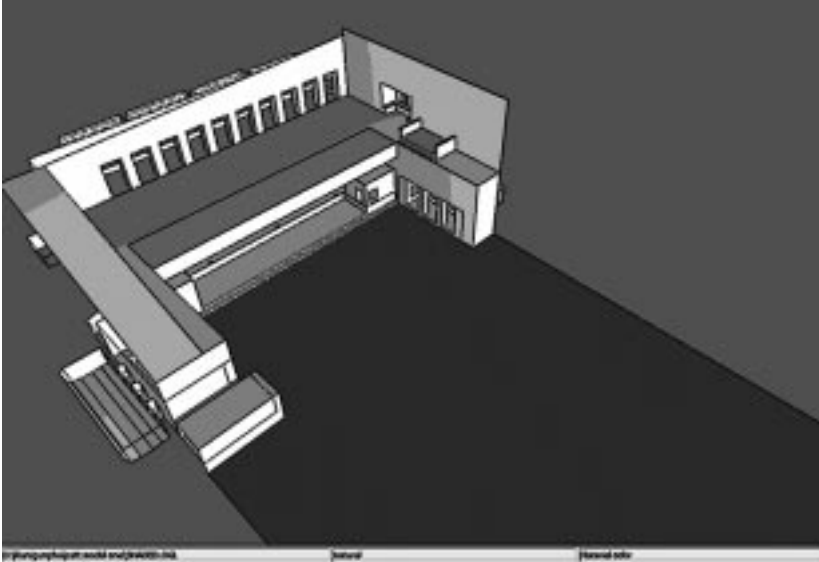
It is now over six years since we started on this project, to measure the acoustics of Ranigumpha, and build a computer model to evaluate its properties. We now have a nearly complete model of the structure, built under CATT acoustic software.<sup>6</sup> There are two ver-



sions of this model, one with a wooden stage extension that no longer exists and the second without. Other models, removing and modifying various elements of this very complex structure, will also be built. A new set of acoustic measurements were carried out in June last year, using a combination of new software and a portable kit that can be useful in many remote and inaccessible locations. Primarily, the measurements go to confirm the aural quality of this space: putting numbers on the extraordinary quality of the sound that anyone can hear.

We have simultaneously been building an acoustic model of the structure using CATT acoustic software and comparing the results generated by the model with those obtained at the site.

There are several reasons for building this model. First, one can separate the complex of interactions in the structure to try to define which parts of the building provide which elements of the sound. A second, more fascinating, proposal is the modification of the struc-



ture. Ranigumpha was carved out of rock. By simulating this process in the model, carving the structure again, step by step, we should be able evaluate the acoustic properties of the structure in the intermediate stages, all the way to completion.

We think the builders of Ranigumpha proceeded the way a maker of musical instruments does. The shape of the structure was predetermined, but the fine details were determined by the sound they heard from the structure. The builders stopped excavating further when the sound came out right. By building this structure again, and listening to its sound, one might learn something of the aural acuity of its builders.

We are not proposing that the builders of Ranigumpha (or other ancient sites in India and elsewhere in the world) possessed better hearing than us, or that they had early and better version of acoustics. What they did have to their advantage was an acoustic environment that was just very much quieter. No machinery noise, no traffic, not even too many humans!

Reverberation tails that now disappear into the general background noise, small changes in colouration, would have been very much more obvious then.

There are a few uncertainties regarding this model; in particular, we are not certain of the acoustic properties of the material used, a kind of sandstone that has, over two millennia of exposure, turned porous and crumbly.

Nevertheless, the model does reflect fairly well the acoustic properties of the site; in particular, the change in acoustic from on-stage to off-stage.

In terms of the CATT model of Ranigumpha, we hope to elicit responses from musicians, musicologists and other scholars. We are also planning to improve the measurement kit a little more to produce more reliable and repeatable acoustic measurements of ancient sites, and use this to measure several more possible sites in India. In the long run, we hope to address some major puzzles in India's cultural history.

Beginning from the 5<sup>th</sup> century BC, there are numerous references in Indian literature to theatre, actors, and performances. Panini's fifth-century BC grammar uses the speech of actors to illustrate grammatical structures. The *Kamasutra* (second century BC) sets out in detail the responsibilities of a citizen (*nagarika*) towards actors and their maintenance. Bharata's *Natyasastra*, compiled between the third century BC and the third century AD, is the world's oldest manual on theatre. It is also very comprehensive, beginning with the construction of theatres and going on to forms of theatre, dance, music, poetry and figures of speech.

<But where are the theatres?>

In all the countless monuments excavated and preserved in India, only two have been tentatively identified as 'theatres', and these definitions have not been universally accepted. We have been measuring and modelling one of the two sites, and we plan to extend this to the other possible theatre sites at Sitabenga in Ramgarh hills.<sup>7</sup>

Our aim is to measure and model the acoustic properties of as many early sites as possible (by early we mean the period between 3<sup>rd</sup> century BC to 3<sup>rd</sup> century AD). We do not wish to suggest that acoustics will completely answer one of the puzzles of archaeology, but we do hope it will provide clues.

Research in the last fifteen years has begun to unveil a fascinating chapter. The period is around the fifth century BC, when religion transformed itself from Vedic Hinduism to a system of more universal appeal, from esoteric rituals of sacrifice to public and popular worship and prayer. At least one author writing of this period suggests that theater played a mediating role in this transition, and the first representations of gods in fact occur not as stone images but as masked and painted actors. She also suggests that the reason no theatres have been found so far is because we have looked for the wrong kind of structures.<sup>8</sup>

Perhaps a deeper appreciation of the role acoustics might have played in the structures built in this period would help in this search.

Photos and drawings by Uma Shankar.

## NOTES

1. Dr. C. Thomas Ault, a theatre historian now teaching at the Indiana University of Pennsylvania.
2. By this time, I was sitting in in Dr Ault's house in the US, more for undisturbed peace than for technological assistance. I met Dr. Leo Beranek in Boston, as well as students and professors of anthropology, archaeology, and ancient mathematics at Brown University. I also made contact with the Acoustical Society of America, where David Lubman was trying to organise the first special session on ancient acoustics. Meanwhile, Dr. Angelo Farina of the University of Parma offered free software and to check my measurements. He also offered to publish a joint paper on the subject. Dr. Bengt Ing Dalenbeck, author of the modelling software, got

in touch and asked to look at my model so he could evaluate it. (I wonder if anything at all would have happened without the Internet? These, and other people I have never met, have genuinely been my collaborators in this project.)

3. With new measurements, with the completed acoustic model, Dr. Ault and I went to Mexico for a new session of ancient acoustics. This is a brand new science, but we now have a large group of 25-50 people interested in it. We also have at least some tools, and the first book in this discipline (Devereux, *Paul Stone Age Soundtracks: The Acoustic Archaeology of Ancient*) has been published; and we even had the press interviewing some of us!

4. A major inscription in one of the caves at this site, *Hathi Gumphā*, links it to King Kharavela of Kalinga. Many of the words in the *Hathi Gumphā* inscription are effaced and there is considerable disagreement about their meaning. The following does come through:

From line 5 we learn:

"Expert in the Gandharva Veda, or in all histrionic arts himself, Kharavela arranged the entertainment of his citizens, items such as *Dapa* (combats), *Nata* (dance), *Gita* (vocal music), *Vadita* (orchestral music), *Usaba* (festivals) and *Samaja* (plays)."

Line 13 informs us that:

"Kharavela built in his kingdom *Vithi* (roads), *Jatara* (theatre), *Paligkhani* (canals), *Gopurani* (gates), *Siharani* (temples), etc."

In line 16 we are told:

"(His majesty) revived the *Tauryatrika* (performance of song, dance and concert) included in the sixty-four branches of art, which had been suspended during the time of the Mauryas."

5. Ranigumpha is one of a number of ancient performance spaces in India. Theodore Bloch was the first to comment on these spaces in his report to the Archaeological Survey of India. In 1884, he identified the performance spaces at the Sita Benga and Yogi Mara caves just outside Ramgarh and noted Greek influence in the configuration of the seating arrangement. Commenting on Khandagiri, Bloch said: "As a matter of fact, we find traces of dramatic representation in the cave inscriptions of Nasik during the time of Siri Pulamai (2<sup>nd</sup> century A.D) and in the Hathi Gumphā inscriptions of Kharavela of Kalinga" (Bloch, 1917).

6. [www.catt.se](http://www.catt.se)

7. As I write this paper, I have just heard there is a book out on the theatre at Ramgarh.

8. Lidova, Natalia *Drama and Ritual in Early Hinduism* (Motilal Banarasidas, 1994, Delhi).