Why do Rocks Ring?

Vibration makes sounds.
Objects make a sound when they are hit because they vibrate.

Vibrations and Sound

A vibrating object moves the air molecules closest to it, pushing them together as the object moves in one direction, then pulling them apart as it moves the opposite way. These air molecules collide with their neighbours causing a wave to propagate. When the air's vibration reaches the ear, the eardrum vibrates and our brain processes this as sound.The vibration produced when we strike most objects quickly diminishes and we hear only a dull thud. However, some objects are able to sustain vibrations and these will ring. We can stop a ringing rock key by touching it, because we stop or *dampen* the vibrations.

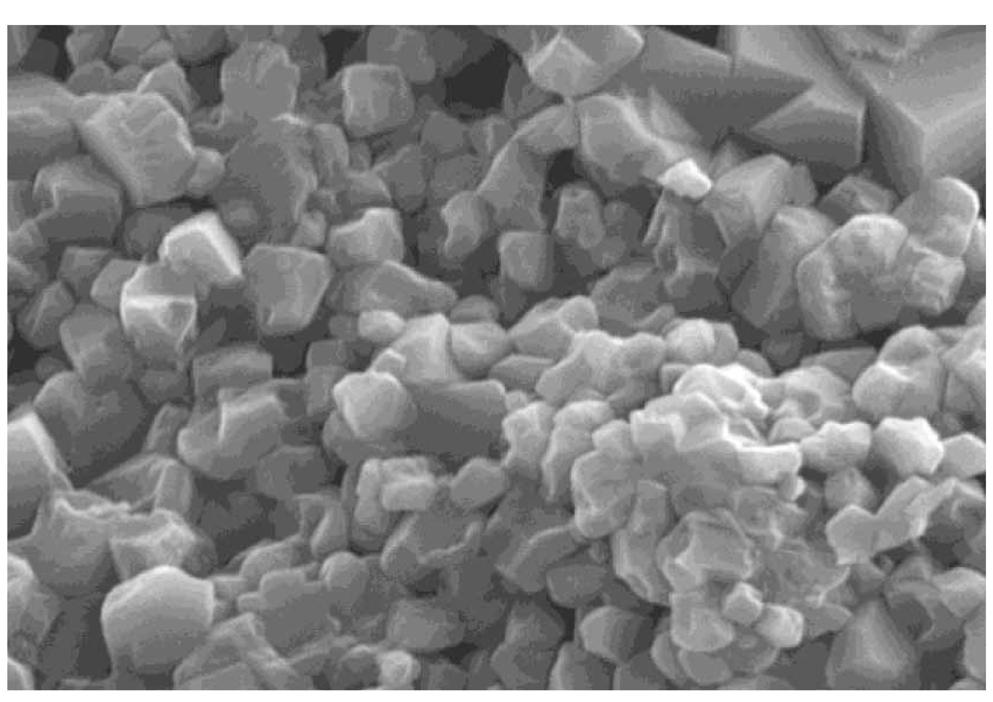
The rate at which the rock keys vibrate determines the *pitch* of the sound. Imagine waves breaking on a beach; you can count the number of waves that break every minute and that gives you the frequency of the waves. Vibrations in the air reach the ear as a series of waves, but the frequency of these waves is much greater than for waves on the beach. The more vibrations, the higher the frequency and so the higher the pitch of the sound that we hear.

Most sounds we hear do not consist of a single frequency, but are made up of many frequencies at different intensities. The changing combinations of frequency and intensity (the *spectrum*) determine the colour or *timbre* of the sound.

Rock Sound

For a rock to ring, the grains must be grown tightly together so that vibrations pass from one grain to the next without losing energy. If there are pores or spaces between the grains, the vibrations will not be able to pass across and the sound will be lost. A cracked rock will make a noise when struck, but does not ring. A sandstone that is full of holes between the grains will make little noise and will never ring.

The rock keys' thickness and length both influence the rate of vibration. The shorter keys make a higher note. If we halve the length we get four times the frequency (the same note but two octaves higher).



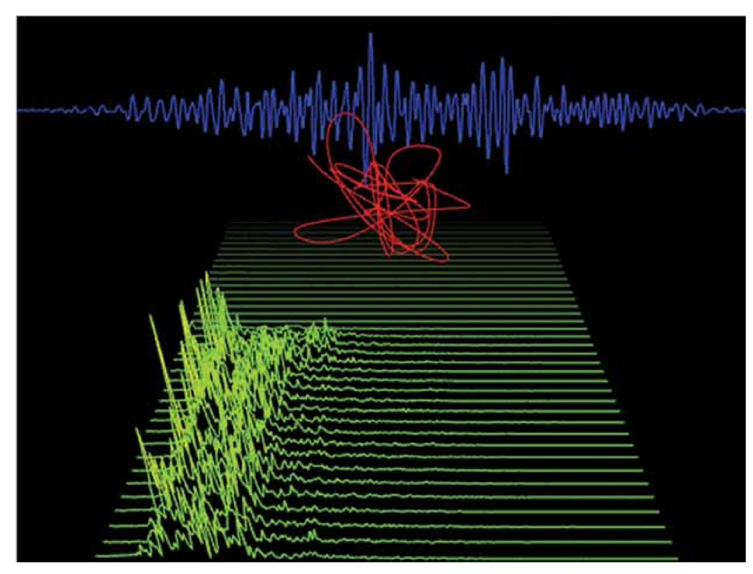
Scanning Electron Microscope image showing the crystalline structure of a fine-grained ringing limestone. The field of view is approximately three hundredths of a millimetre.

An Introduction to the *iRock*

The *iRock* (interactive Rock) is an interactive multimedia instrument which explores the natural beauty of rock vibrations through the rich geological diversity of Cumbria. The *iRock* software contains a database of information and images for each rock type including Scanning Electron Microscope images of the crystalline structure. The vibrations from each individual key of *iRock* are monitored continuously. If a strike is detected, the computer software goes into action, displaying images and information about the rock key.

Audio Visualisations

The left side of the *iRock* screen shows different visualisations of the *iRock* sounds. The waveform display in blue (top) shows the vibrating pressure waves radiating from the *iRock* keys.



Real-time sound visualisations.

The frequency spectrum of these vibrations is sampled continuously, to create a scrolling representation of the sound shown in green (bottom). Each green line has peaks corresponding to the frequencies of the vibrations that are detected at a particular instant in time. Illustrating the harmonic structure of the sound is a *Lissajous* plot, shown in red (middle). This is a curved shape that reflects the complexity of the note and shows how the sound changes as the key continues to ring. The strike with the beater creates many frequencies and the plot is a complex knot that rapidly changes. As the sounds decay to leave only the fundamental frequency, the plot takes on a simple elliptical shape – illustrating that a single frequency now dominates the sound.

Try gently hitting an *iRock* key – and watch how the waveform reacts.

The Future

The *iRock* is a prototype. It can be set up with different keys of varying pitch and timbre. The *iRock* software can provide various visualisations, information and audio augmentations for geology and music. At the University of Leeds Interdisciplinary Centre for Scientific Research in Music (www.ICSRiM.org.uk) we are studying how to augment the sound, and elongate the signal, enhancing the natural vibrations whilst preserving the original sonic qualities which give rock its distinctive tone.

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Brantwood
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Further information at **www.ruskinrocks.org.uk**