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SCG69-P02 Room:Convention Hall Time:May 24 17:15-18:30

Radio wave emission from 1 MHz to 18 GHz due to rock fracture and the estimation of the emitted energy

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1. Introduction

Formerly, the microwave emission due to rock fracture was reported from 300 MHz to 22 GHz [1]. We started experiments adding the 1 MHz receiving system in order to gather more data and to study the relation with lower frequencies [2].

This paper describes the measurement results of the radio wave emission from 1 MHz to 18 GHz. The estimation of the emitted energy that may be difficult to understand will be carefully explained. Then, the estimated result is presented.

Lastly, it is shown that this research work may be effective as disaster measures through the detection of earthquakes and volcanic activities.

2. Measuring system

At 1 MHz, a loop antenna and a receiver of direct reception are adopted. The relation between the input power and the indication on an oscilloscope for the antenna and receiver was calibrated using the radio wave of a broadcasting station at 954 kHz (wavelength of 314 m). The distance R is 37.2 km. Therefore, the power density of the radiated radio wave from the station is obtained by geometrical calculation.

On the other hand, in a laboratory experiment, the distance between a rock sample and an antenna is only 1 m, which is much shorter than a wavelength. As a result, the emission from a destroyed rock is expressed as a near field rather than a far filed. We convert the near field value to the far field value, then verify the energy relation.

3. Received waveforms

Figure 1 show an example of the received waveforms. In the coarse time axis in the figure (a), the waveform looks like pulses. Most pulses occurred at the same time as the pulses in the other frequency bands. The expanded waveform at 1 MHz in the figure (b) includes sinusoidal change at the frequency of 1 MHz, and its envelope attenuates exponentially.

4. Estimation of the emitted energy

The procedure is as follows:

(1) With an input power to a receiver, calibrate the voltage value on an oscilloscope.
(2) In the rock destruction experiment, read the voltage of a signal on the oscilloscope.
(3) Assuming the received signal to be a continuous wave, obtain the equivalent received power.
(4) Using the values of free space loss and the receiving antenna gain, calculate the equivalent power of the emitted radio wave.
(5) Using the signal duration or a pulse width, convert the equivalent power of the emitted radio wave to the emitted energy.

In the lecture, the concrete procedure and results of the estimation will be given.

5. Applicability of the experimental results to earthquake detection

The earthquake prediction has been officially stated impossible. On the other hand, many technologies and knowledge appear in the surroundings of seismology. The radio wave emission phenomenon due to rock fracture is one of them.

By receiving the emitted radio wave due to rock fracture and friction, we can detect an earthquake or volcanic activities. If the rock is destroyed before the ground quake, the radio wave indicates real prediction. Even if the rock destruction and the ground quake occur simultaneously, we can give an effective alarm against disaster because of a large delay time difference between the radio wave and seismic wave.

The relation between rock fracture and the ground quake is hardly clarified, and is rendered to seismologists and geologists for a future research. Seismology and seismo-electromagnetics should cooperate in this field.

6. References

[1] K. Maki et al., "An experimental study of microwave emission from compression failure of rocks", Jour. of the Seismological Society of Japan, vol.58, no.4, pp.375-384, 2006.

[2] T. Takano et al., "Restructuring of the Measuring System of Microwave Emission Due to Rock Failure and Preliminary Experimental Results", Seismological Society of Japan, Fall Meeting, B11-05, Shizuola, October 2011.

Keywords: radio wave emission, rock fracture, emitted energy, estimation, pulse waveform, earthquake detection

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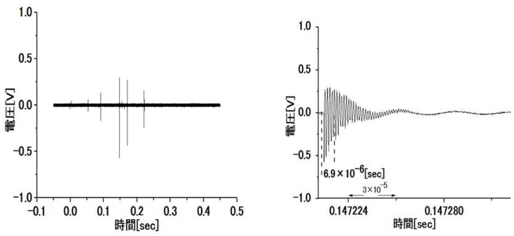

(a) Packed waveform (b) Expanded waveform

Fig. 1 Waveforms from quartzite at 1 MHz-band.