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Experiment Method of Microwave Detection in Association with Rock Fracture and Energy Consideration of the Obtained Data

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Formerly, microwave emission was found when a rock was compressed to be broken. At first, it was assumed secondary phenomena of piezoelectricity. However, experiments of several kinds of rocks revealed that the emitted power is not proportional to the content of quartz.

This paper first describes the detection and measurement method of microwave emitted in association with rock fracture. Then, experimental data is investigated from the viewpoint of generated energy.

Several kinds of rocks were pressed with a compressor to destruction. The samples are quartzite, granite, gabbro, and basalt. In the receiving system, the signal is amplified by a low noise amplifier first, sampled by a sufficiently high sampling frequency. Then the digitized data are stored. Observation frequency was 22GHz, 2GHz, 300MHz, and 1MHz.

Difficult points of the measurement are as follows:

1. Quite high frequencies should be treated. The ever-tried frequencies are 300 MHz, 2 GHz, and 22 GHz, which are much higher than the frequencies treated in usual geophysics.

2. In microwave measurement, impedance matching is inevitable. This is one of most difficult items in electrical measurements.

3. The phenomena are instantaneous, and lasts typically less than one msec. This fact is more serious than usual microwave measurements. We have to record the signal with an accurate triggering device.

4. The obtained signals suggest quite wide frequency band, which exceeds technological capability for only one wide-band receiver to cover the whole band. Therefore, we have to divide the total frequency band to several sub-bands, and use heterodyne receiving technology if necessary.

5. As the high frequencies are enclosed in the envelopes, we have to investigate carefully the original signal waveform and power.

6. In order to calibrate the emitted power, special knowledge of waveform of band-limited signal is needed.

In the receiving system, special care is required for microwave detection. The signal is first amplified by a low noise amplifier, digitized in a sampling frequency high enough for the observed frequency, and then stored as data. The observed frequency is 22GHz, 2GHz, 300MHz and 1MHz. If the data storage capacity is too small to keep the data for a required observation time, namely at 22GHz and 2GHz, the signal is converted to a lower frequency by a heterodyne receiver and then processed to data.

The observed microwave is intermittent pulse in every case. The width of each pulse is quite narrow, 2 nsec at the highest frequency of 22 GHz. For most kinds of rocks, 22 GHz was not detected, but the other frequencies were all observed. The pulse group just after the rock fracture and the pulse group later generated sporadically are different each other in terms of time interval between the emissions and emitted energy.

As the waveforms thus obtained are almost sinusoidal in shape, we can calibrate the power through the receiving system. From the results, we calculate the radiated power per a unit frequency for each frequency band. As for the pulse group just after the rock fracture, quartz has the maximum emission at 2GHz-band in all frequencies while gabbro has the maximum at 300MHz-band. As for the averaged value over the observation time, quartz has the shifted maximum at 300MHz-band while gabbro has the maximum at 300MHz-band unchanged.

This discovery is the world first so that we have to clarify the characteristics such as dependency on several parameters.

Keywords: Rock fracture, Microwave emission, Pulse, Detection experiment, Receiver, Energy consideration