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Electromagnetic Signals Associated with Fracture of Rocks at High Confining Pressures

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Various electromagnetic anomalies have been reported as potential candidates for a precursor signal of earthquakes and several physical models for the mechanism that generates the observed anomalous signals were proposed. It can hardly be said, however, that the possible theories have been established for the mechanism of the observed electromagnetic phenomena. In laboratories, many types of experiments have been performed to evaluate the proposed models, however, tests performed at a confined pressure condition are limited. In this study, we performed two types of deformation experiments on rocks, fracture experiments and frictional experiments, at high confining pressures to 100MPa within a pressure vessel, simulating deep focal depth conditions of earthquakes. We tried to measure electromagnetic signals associated with deformation of the tested specimens inside the pressure vessel.

Fracture experiments were performed at room temperature on dry, cylindrically shaped specimens of granite, basalt and gabbro (20mm in diameter, 50mm in length) at confining pressures to 100MPa. Electric signals were recorded as an electromagnetic field change between two electrodes of copper plates (30x30mm) and of a coil set around a specimen. In addition to the fracture experiments, we performed frictional sliding experiments at room temperature on dry, cylindrical specimens of the same rock samples with a precut surface at an angle of 30 degree to the cylindrical axis, with loading rate of about 0.003 mm/sec and at confining pressures to 100 MPa. Experimental results showed that at the moment of main failure of the fracture experiments, intense electromagnetic field change were observed for all tested specimens even for the samples that contain no quartz. Detected record showed that the electromagnetic emission from granite has a wide frequency range to MHz and characterized by its dominant frequencies at around 200 – 300 kHz. Electromagnetic signals from basaltic rocks are characterized with lower frequency ranges than the signal from granitic rocks. Preliminary results of the friction experiments also showed that a certain amount of electromagnetic signals do appear upon the slip motion of the tested rocks during stick-slip mode sliding.

For quartz-bearing rocks such as granite, the piezoelectric behavior of quartz should contribute to some extent to the observed electromagnetic signals accompanying the deformation of dry rock samples. Tested results, however, confirmed that there are other important contributing factors to the observed signals during the fracture and/or frictional sliding of rocks at high confining pressures.