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# Generation of Electromotive Force and Changes of Seebeck Coefficient on Igneous Rocks under Non-uniform Stress

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To study mechanisms of electromagnetic phenomena related to earthquakes, we have conducted laboratory experiments using rock samples. According to our previous experiments, when a terminal of an air-dried igneous rock block is uniaxially loaded, there appears the electromotive force making electric currents flow from the stressed volume to the unstressed volume. There is a positive correlation between the degree of stress/strain and the electromotive force. Because quartz-free gabbro tends to generate the stronger electromotive force than quartz-rich granite, it is inconsistent to consider piezo-electric effect as the main factor of this electromotive force. To explain this force, we have focused on peroxy bonds: one of the most popular lattice defects in igneous rock-forming minerals, e.g., $O_3Si\text{-}OO\text{-}SiO_3$ in quartz. When this bond is deformed by mechanical force, an antibonding energy level of this bond shifts down into the Valence band and an electron can jump in this level from a neighbor oxygen site. As a result, a positive hole is activated in this neighbor site and an electron is trapped in the deformed peroxy bond. Once positive holes are activated, they can spread away through the Valence band. Though we have expected that the positive holes flowing from the stressed volume to the unstressed volume be the source of the electromotive force induced by non-uniform stress, the activation/spread of positive holes is not yet proved. In this study, we measured thermoelectromotive force of air-dried gabbro blocks whose one terminal was uniaxially loaded/unloaded. We verified the activation/spread of positive holes from the increase/decrease of the Seebeck coefficient during loading/unloading. The results indicated that the Seebeck coefficient of the gabbro without loading was about 0.8-1.2mV/K, meaning the majority of charge carriers are hole. On the other hand, the Seebeck coefficient of the volume under 60MPa of stress decreased to about 0.5-0.7mV/K, and that of the volume under stress free did not remarkably change, i.e., about 0.8-1.2mV/K. This meant that the concentration of holes increased in the stressed volume and such a change was little in the unstressed volume. In conclusion, it was clarified that holes were activated in the stressed volume and the distribution of the holes spreading reached only near around the stressed volume. Provably, only a little part of the holes reached the unstressed edge. The small slant in the distribution between these holes and the electrons trapped at the deformed peroxy bonds, i.e., the electric polarization in the stressed volume, is the source of the electromotive force induced by non-uniform loading. An increase of the stress/strain degree causes an increase of the positive hole concentration, leading increases of the electric polarization and the electromotive force. In the Earth's crust, a change of stress/strain in and around a fault before/during faulting will cause the activation/spread of positive holes, leading a change of polarization and a formation of an abnormal electric field in and around the fault.

Keywords: Seismo-electromagnetics, Igneous rock, Electromotive force, Lattice defect, Positive hole