

A Mechanochemical Model of Stress-induced Charges for Generating the Electromagnetic Precursors of Earthquakes

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Abstract The generation of electric currents on the ground surface or in the shallow depths of upper crust inside and near the fault zone, where an impending earthquake will happen, is a necessary condition to produce the electromagnetic precursors of earthquakes. Such currents could be generated due to the presence of stress-induced charges. From laboratory experiments, Freund (cf. 2013) assumed that the stress-induced charges are caused by peroxy defect in the fault-zone rocks. He also proposed a peroxy defect theory to interpret the observations. To further interpret such a theory for the generation of stress-induced charges, a model based on mechanochemistry (Gilman, 1996) is considered in this study. Stress-induced generation of charges can be regarded as a kind of phase transition, which can be studied by using the Gibbs free energy (Gibbs, 1873): $G(p,T)=U+pV-TS$ in which U , p , V , T , and S are, respectively, the internal energy, pressure, volume, temperature, and entropy. According to the Landau theory (Landau, 1937), the G for a structural transition can be described by a single-order-parameter function (see Sornette, 2000): $G=bQ^4/2-aQ^2+fQ+dQ\varepsilon+h\varepsilon^2/2$, in which Q is a scalar one-order parameter; a and b are two phenomenological coefficients for the phase transition; the f controls the breaking of symmetry between two phases; the d quantifies the strength of the coupling between Q and strain; and $h\varepsilon^2/2$ is the elastic energy density of the material with elastic modulus h . Analytical and numerical solutions based on this function will be performed for studying the intrinsic properties of the model and the possibility of stress-introduced electric current. Preliminary results reveal that the G function shows a symmetric double-well configuration as $f=0$, $d=0$, and $\varepsilon=0$; the parameter f and d break the symmetry of the function; and $h\varepsilon^2/2$ will shift the configuration upward. An increase of ε will make the phase state related to a solution change from the stable state, the metastable state, finally to the unstable state. This can explain stress-induced charge generation on a rock under external loading.

Keywords: Earthquake E&M Precursor, peroxy defect, stress-induced charges, mechanochemistry, phase transition, free energy.

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