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Moving Charged Dislocations and Pressure Stimulated Currents. From fracture processes to earthquake physics: A review

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The possibility of electrical earthquake precursors (EEP) has long been appreciated, but it has proven difficult to construct a solid theory to describe their generation and expected characteristics, or proven techniques to identify and discriminate true precursors from noise. To this end, a large number of laboratory experiments have been conducted, which have demonstrated the generation of transient electric potential prior to rupture in both dry and wet rock specimens. The principal mechanisms proposed to explain these observations are the piezo-electric and electrokinetic effects. The piezoelectric effect, often quoted in the literature as the principal generator of EEP, cannot explain why non-piezoelectric rock specimens also generate precursory electric phenomena. Streaming potential can be generated in many kinds of saturated rocks, but the fracturing of dry rocks also produces transient electric effects. Therefore, these two mechanisms may not be the basic contributors to the precursory phenomena observed in the laboratory (and to possible EEP signals). Herein we present a series of laboratory experiments on the microfracturing electrification of dry marble samples under stress, and discuss their possible relationship to field observations of purported EEP.

The marble samples were subjected to uniaxial compression,at constant and variable

stress-rates, in both the elastic and the plastic domains. During the experiments, pressure stimulated currents (PSC) were observed. The PSC was linearly related to the stress rate, so long as the stressed material deformed elastically. Deviation from linearity arose when the specimen was driven into the plastic deformation range; this effect has been counterparted with the dependence of the PSC on the stress rate and, ultimately, with the inverse of the changing (decreasing) Young's modulus. The emitted current appears very intense and non-linear just prior to failure. The dependence of the emitted pressure stimulated currents on the stress rate and the Young modulus of the material was thus demonstrated. Repeated cycles of deformation are associated with progressively weaker current emission, indicating the strong dependence of electrification on the residual damage (hence Young modulus). Explanation of these observations was attempted with a theoretical model involving microfracturing and the Motion of Charged edge Dislocations (MCD) as the primary electrification mechanism (see Tzanis and Vallianatos, 2002). The PSC waveforms and mode of appearance accord with the predictions of the MCD model and it appears that *if* this process could scale up to the size of seismogenic zones, it would yield observable EEP. The MCD model also makes specific predictions of the waveforms of the expected EEP signals.

Furthermore some resent results based on the statistical description of PSC from rock fracture experiments obtained from samples of calcite are presented. In all considered cases, the waiting time distribution can be described by a unique scaling function. A frequency-energy distribution similar to the well known from Seismology Gutenberg-Richter law was obtained, as well as an accelerating power-law time-to-failure behaviour of energy release rates, also analogous to the well known acceleration of cumulative Benniof strain, observed prior to large earthquakes. The resulting scaling functions are similar with those for earthquakes and acoustic emissions and are strongly suggestive of the universality in the manifestation of fracture processes and derivative effects.

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