Geophysical Research Abstracts,
Vol. 10, EGU2008-A-07041, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-07041
EGU General Assembly 2008

Evidence of Universality of Scaling in Pressure Stimulated Currents related to Rock Fracture

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Despite the large amount of experimental data and the considerable efforts undertaken, many questions about fracture have not yet been answered. The fracture phenomena, particularly those concerning inhomogeneous materials, in association with transient electric phenomena, attract the interest of the scientific community. The main reason is that such phenomena are promising candidates of earthquake precursors. It is well accepted that during the development of the material deformation, there appear mechanisms of generation of electric signal emission and a number of researchers acknowledge such mechanisms as related to crack generation. In order to understand the mechanisms that produce these electric signals, a number of laboratory experiments of mechanical stress up to sample fracture have been conducted on minerals and rocks (dry and saturated) .

The laboratory studies on emitted electric signals from rock specimens at the time of fracture, suggest a variety of mechanisms through which these signals are produced. Among the reported mechanisms piezoelectric effect of quartz, electrokinetic effect due to water movement, point defects, emission of electrons and moving charged dislocations are included.

Recently, a series of laboratory experiments conducted on calcite samples have confirmed that the application of a uniaxial stress is accompanied by the production of weak electric currents that has been described by the term Pressure Stimulated Currents (PSC). In particular, Pressure Stimulated Currents and Acoustic Emission (AE) due to microcrack growth precedes the macroscopic failure of rock samples under constant stress or constant stress rate loading.

In the present work we show that despite this difference the scaling law of frequency-size distribution, the probability density function (PDF) for the time interval between PSC events and an analogue of Benioff type law are similar with that observed in AE and seismicity.

In particular, the PDF for the time interval between pressure stimulated currents emitted during laboratory rock fracture experiments strongly suggest a universal character of the waiting time distribution and self-similarity over a wide range of activity in rock fracture. Furthermore, since the AE due to microcrack growth follow similar laws as PSC, it can be considered indicative that the moving charge dislocations (i.e., growthing microcracks) is the driving mechanism of PSCs. We analyse the PSC time series of laboratory rock fractures obtained from different compressed experiments in calcite and cement samples at two modes a) at constant stress and b) at a constant stress rate.

Acknowledgements

This work is supported by the project MILD-MAP, Measure 3.3 “Management, prevention and reduction of natural risks: drought, desertification, fires, earthquakes etc.”, Priority Axis 3, ARCHIMED, INTERREG IIIB, co-financed by the European Regional Development Fund (ERDF) and national resources.