Geophysical Research Abstracts
Vol. 15, EGU2013-10426, 2013
EGU General Assembly 2013

# Deformation and failure of single- and multi-phase silicate liquids: seismic precursors and mechanical work

Jeremie Vasseur (1), Yan Lavallée (2), Kai-Uwe Hess (1), Joachim Wassermann (1), and Donald B. Dingwell (1)

(1) Earth & Environmental Sciences, Ludwig Maximilian University, Munich, Germany (jeremie.vasseur@min.uni-muenchen.de), (2) Earth, Ocean & Ecological Sciences, University of Liverpool, Liverpool, UK (yan.lavallee@liverpool.ac.uk)

Along with many others, volcanic unrest is regarded as a catastrophic material failure phenomenon and is often preceded by diverse precursory signals. Although a volcanic system intrinsically behave in a non-linear and stochastic way, these precursors display systematic evolutionary trends to upcoming eruptions. Seismic signals in particular are in general dramatically increasing prior to an eruption and have been extensively reported to show accelerating rates through time, as well as in the laboratory before failure of rock samples. At the lab-scale, acoustic emissions (AE) are high frequency transient stress waves used to track fracture initiation and propagation inside a rock sample. Synthesized glass samples featuring a range of porosities (0 – 30%) and natural rock samples from volcán de Colima, Mexico, have been failed under high temperature uniaxial compression experiments at constant stresses and strain rates. Using the monitored AEs and the generated mechanical work during deformation, we investigated the evolutionary trends of energy patterns associated to different degrees of heterogeneity. We observed that the failure of dense, poorly porous glasses is achieved by exceeding elevated strength and thus requires a significant accumulation of strain, meaning only pervasive small-scale cracking is occurring. More porous glasses as well as volcanic samples need much lower applied stress and deformation to fail, as fractures are nucleating, propagating and coalescing into localized large-scale cracks, taking the advantage of the existence of numerous defects (voids for glasses, voids and crystals for volcanic rocks). These observations demonstrate that the mechanical work generated through cracking is efficiently distributed inside denser and more homogeneous samples, as underlined by the overall lower AE energy released during experiments. In contrast, the quicker and larger AE energy released during the loading of heterogeneous samples shows that the mechanical work tends to concentrate in specific weak regions facilitating dynamical failure of the material through dissipation of the accumulated strain energy. Applying a statistical Global Linearization Method (GLM) in multi-phase silicate liquids samples leads to a maximum likelihood power-law fit of the accelerating rates of released AEs. The calculated $\alpha$ exponent of the famous empirical Failure Forecast Method (FFM) tends to decrease from 2 towards 1 with increasing porosity, suggesting a shift towards an idealized exponential-like acceleration. Single-phase silicate liquids behave more elastically during deformation without much cracking and suddenly releasing their accumulated strain energy at failure, implying less clear trends in monitored AEs. In a predictive prospective, these results support the fact that failure forecasting power is enhanced by the presence of heterogeneities inside a material.