Discrete Element Analysis of Acoustic Emission activity during Progressive Failure in Berea Sandstone

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We investigate possible indicators of critical point behavior during damage localization in brittle rocks using statistical properties of Acoustic Emissions (AE) released by growth of microcracks. Biaxial deformation experiments are simulated upon calibrated samples of Berea Sandstone under constant confining pressure conditions using the Discrete Element Method. We monitor the spatial and temporal distribution of microcracks occurring in tensile and shear modes during ten experiments over confining pressure conditions of 0 to 45 MPa. Energy associated with microcracking activity is used to characterize AE activity quantitatively using the frequency-magnitude relations (b-value), fractal dimension of hypocenters (D-value) and Omori’s Law (p-value). Our results reveal four distinct temporal phases of AE activity and fracture growth, each clearly identifiable from the above parameters. Damage evolution prior to catastrophic failure is characterized by 1) an increase in rate of AE energy release, 2) an increase in shear microcracking, 3) a decline b-value, and 4) a decline in D-value. We observe a characteristic pre-failure increase in differential stress and shear microcracking along the process zone of the eventual fracture, resulting in the decline in b-values and D-values. The integrated analysis of microcrack mode and statistical AE parameters can be used to predict the critical point for brittle failure. We will conduct a sensitivity analysis using unsupervised machine learning techniques to analyze the relative importance of the calculated seismicity indicators to develop a robust methodology to predict brittle failure.