DYMANICRUPTUREINDAMAGE-BREAKAGERHEOLOGYMODEL

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We present a thermodynamically-based formulation for modeling dynamic rupture processes in the brittle crust using a continuum damage-breakage rheology. The model combines aspects of a continuum viscoelastic damage framework for brittle solids with a continuum breakage mechanics for granular flow within dynamically generated slip zones. The formulation accounts for the density of distributed cracking and other internal flaws in damaged rocks with a scalar damage parameter, and address the grain size distribution of a granular phase in the slip zone with a breakage parameter. A dynamic brittle instability is associated with a critical level of damage in the solid, leading to loss of convexity of the solid strain energy, localization, and transition to a granular phase associated with lower energy level. The continuum damage-breakage rheology model treats the localization to a slip zone at the onset of dynamic rupture and post-failure recovery process as phase transitions between solid and granular states. The model generates sub- and super-shear rupture velocities and pulse-type ruptures seen also in frictional models, and additional important features such as strong dynamic changes of volumetric strain near the rupture front and diversity of nucleation mechanisms. The propagation of rupture front and slip accumulation at a point are correlated with sharp dynamic dilation followed by a gradual decay to a level associated with the final volumetric change associated with the granular phase transition in the slipping zone. The local brittle failure process associated with the solid-granular transition is expected to produce isotropic radiation in addition to the deviatoric terms. The framework significantly extends the ability to model brittle processes in complex geometrical structures and allows analyzing the roles of gouge thickness and other parameters on nucleation, rupture and radiation characteristics.