Brittle fracture in porous media: ceramics, paper, and earthquakes

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ABSTRACT: Many porous media, natural and engineered, fail upon external loading by means of brittle fracture. This implies that, under ideal conditions, the statistical distribution of the strength variable is the Weibull distribution. Nevertheless, the experimental data often exhibit deviations from the Weibull behavior in the tails of the distribution. First, we review the weakest-link theory that provides a widely used model for the strength of brittle materials. Then, we discuss some recent proposals for deviations from the ideal Weibull behavior. Next, we propose modifications of the weakest-link theory for finite-size systems that lead to power-law tails of the strength distribution. We compare the new expressions for the probability density function of finite-size systems with expressions that have been derived in special relativity and recent theories of quasi-brittle fracture. We also develop a stochastic stick – slip model that connects the crustal shear strength of the Earth with the waiting times between earthquake events. The crust is composed of porous material (rock), and the existing data point to the Weibull distribution as a suitable strength model. We argue that the Weibull distribution, which is empirically used for the distribution of waiting times between earthquakes, is motivated by this dynamic connection. Finally, we present mechanisms which can lead to deviations of the waiting times distribution from the Weibull expression, as observed in certain experimental data.