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Scaling of coupled dilatancy-diffusion processes in space and time

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Coupled dilatancy-diffusion processes resulting from microscopically brittle damage due to precursory cracking have been observed in the laboratory and suggested as a mechanism for earthquake precursors. One reason precursors have proven elusive may be the scaling in space: recent geodetic and seismic data placing strong limits on the spatial extent of the nucleation zone for recent earthquakes. Another may be the scaling in time: recent laboratory results on axi-symmetric samples show both a systematic decrease in circumferential extensional strain at failure and a delayed and a sharper acceleration of acoustic emission event rate as strain rate is decreased.

Here we examine the scaling of such processes in time from laboratory to field conditions using brittle creep (constant stress loading) to failure tests, in an attempt to bridge part of the strain rate gap to natural conditions, and discuss the implications for forecasting the failure time.

Dilatancy rate is strongly correlated to strain rate, and decreases to zero in the steady-rate creep phase at strain rates around 10-9 s-1 for a basalt from Mount Etna. The data are well described by a creep model based on the linear superposition of transient (decelerating)
and accelerating micro-crack growth due to stress corrosion.

The model produces good fits to the failure time in retrospect using the accelerating acoustic emission event rate, but in prospective tests on synthetic data with the same properties we find failure-time forecasting is subject to systematic epistemic and aleatory uncertainties that degrade predictability. The next stage is to use the technology developed to attempt failure forecasting in real time, using live streamed data and a public web-based portal to quantify the prospective forecast quality under such controlled laboratory conditions.