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Inverse power-law like crack growth in earth materials and its possible origin as an emergent property of localisation

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The origin and development of cracks in Earth materials is a subject of general interest and wide application: from seismologists studying earthquakes to engineers studying the strength of materials. Therefore many laboratory experiments have been carried out to investigate the response of rocks to an applied differential stress, often using acoustic emissions (AE) to track intermittent crack growth inside the rock specimen prior to system-sized sample failure. Under a constant applied stress in double-torsion tensile tests with a guide groove and a single dominant crack, independent observations of the stress intensity factor and crack growth velocity imply the size of the largest (sub-) critical crack C grows with time t according to an inverse power-law C(t)=C(0)(1-t/t_f)^{-nu}, where t_f is the failure time and the exponent {nu} is a constant. A similar law holds for the mean crack length in a population of micro-cracks growing under compressional stress with no pre-defined fault plane, often treated using mean field models that ignore localisation of damage clearly seen in the experiments. Here we present a new hypothesis for the origin of this formula by combining expressions for crack population growth and localisation in a single model. The model is tested and some of its parameters inferred from analysis of the AE rate and the spatial clustering of its source locations from laboratory data.