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Drainage fracture networks in elastic solids

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Several geological processes generate large fluid pressures pervasively inside the solid and the fluid is drained out of the solid volume and transported towards the surface by buoyancy. Important examples of this includes dehydrating subducting slabs, hydrocarbon producing kerogen rich shales and partially molten magmas. Such internal production and exsolution of fluids may induce mechanical failure of the solid rock. The resulting fractures provide drainage pathways for the fluid releasing the large fluid pressures.

We have performed analogue 2D experiments with uniform gas production in gelatine. We observe fracture patterns that are topologically intermediate between the tree-like structure of river networks and the hierarchical patterns observed in other transport controlled fracture processes, exemplified by cracks in drying mud, hexagonal columnar joints formed in cooling basalts or sequential splitting of igneous rock due to weathering.

We propose a simple two-parmeter statistical model that captures the essential features of the gelatine experiments and that is able to produce fracture networks ranging in topology from tree-like to hierarchical. The model is explored and compared with the experiments to gain insight into this class of drainage fracture processes. We also present a discrete element model which is used to investigate the effect of fluid-solid coupling on fracture network topology and fluid expulsion.