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Normal faulting in basalts with vertical cooling joints: lessons learned from analogue models and outcrop studies in Iceland

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Normal faults are ubiquitous along mid ocean ridges, and due to the strength of the basaltic rocks, they develop as massively dilatant faults from the surface to a certain depth. Due to their dilatancy these faults act as fluid pathways, which is important for geothermal exploration, hydrocarbon traps, or life deep beneath the ocean floor. However, the strength of basaltic rocks is commonly defined by dense networks of vertical to subvertical cooling joints that create a mechanical anisotropy within the rock body. As a result, conventional modeling techniques using powders or clay fail to accurately reproduce the fault processes and predict subsurface structures.

We present first results of a modeling study using polygonal columns with mechanical anisotropy as modeling material. Drying of a cornstarch slurry forms columns that are geometrically similar to basalt columns as found at mid ocean ridges. We determine mechanical parameters of the dried slurry to provide a mechanical scaling. This allows us to investigate faulting in extensional, hybrid and shear mode faulting.

Results show the formation of several stockworks in the extensional and hybrid domain, where columns break off and get jammed in between the vertical fracture walls. Open cavities underneath the floors exist up to great depths. Compared to faults in isotropic media, the surface geometry is less sinuous on medium to large scale, because the faults can easily follow the path of lowest resistance (little horizontal cohesion). On smaller scale the faults geometry is defined by the shape of the columns and hence more complex than in isotropic media. We finally compare these first results with outcrop observations from faults in Iceland.