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Hydrofracturing dynamics observed in a vertically oriented Hele-Shaw cell

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Characterization and understanding of fracturing dynamics due to fluid injection into rocks is a challenging problem to solve but has numerous potential applications. Typically this issue is looked at in the context of natural hazard understanding, forecasting and mitigation (earthquakes, hydrological processes, volcanic eruptions) or from the industrial perspective (reservoir hydrofracturing, hydrothermal application, CO_2 sequestration). Our experimental setup consists of a vertically oriented rectangular Hele-Shaw cell with three closed boundaries and one semi-permeable boundary which enables the flow of the fluid but not the solid particles. During the experiments, the fluid (pressurized air) is injected into the system with a constant injection pressure from the point near the base opposite to the semi-permeable boundary. At large enough injection pressures, the fluid displaces grains (80 μm grain size) and creates channels and fractures towards the semi-permeable boundary. During the experiments, we change overpressure and duration of the injected air pulse as well as the amount of overburden over the injection point to vary differential stress. The fracture process is recorded by a high-speed camera and analysis is carried out via image subtraction technique. Dynamic evolution of the fracture shows development of both mode I and mode II events. While mode I dominates in the main channel, its opening is differential throughout the lengths of the fracture. This causes shearing of the blocks of mass perpendicularly to the main channel resulting in a multitude of mode II events. Secondly, changes in overburden from larger to smaller makes $\sigma 1$ less prominent, resulting in a switch in fracturing behavior from CLVD to isotropic. Lastly, we are looking at dynamics of the fracturing at its different stages as initially stress release tends to be isotropic and fractures branch out but then the branch that is closer oriented with the direction of $\sigma 1$ tends to become dominant.