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Experimental Investigation of Hydraulic Fracturing and Stress Sensitivity Fracture Permeability under Changing True-triaxial Conditions

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Understanding and predicting fluid flow in rock fractures is critical to geoenergy technologies that harness fracture permeability to produce fluids (e.g. unconventional hydrocarbons or enhanced geothermal systems), as well as those that store buoyant fluid beneath low permeability seals/cap rocks (e.g. carbon capture and storage). We investigate the hydro-mechanical behaviour of hydraulically generated fractures under a range of varying true-triaxial stress conditions and fluid pressures in the true-triaxial Geo-Reservoir Experimental Analogue Technology (GREAT) cell. Hydraulic fractures are generated in both analogue materials and real rocks under true-triaxial conditions representative of shallow (< 1 km depth) subsurface conditions, before hydraulic flow tests are conducted to investigate their hydro-mechanical fracture behaviour. Low permeability analogues are chosen to minimise the contribution of matrix flow so that variations in calculated bulk permeability can be directly related to fracture behaviour in response to stress or fluid pressure changes. Results show that fracture permeability is not only a function of fracture-normal stress, but also of the magnitude of fluid pressure, horizontal stress orientation, and stress state. We find that fracture permeability varies depending on the applied stress state (axisymmetric triaxial vs true-triaxial), and that fractures able to deform in shear show a higher than expected permeability (with respect to normal stress) when critically stressed. This work shows the importance of conducting true-triaxial experiments when investigating fluid flow in fractures and has implications for our conceptual understanding of flow and deformation in fractures.