Please fill in the name of the event you are preparing this manuscript for.	2020 International Petroleum Technology Conference
Please fill in your 5-digit IPTC manuscript number.	IPTC-19923
Please fill in your manuscript title.	The Hydro-Mechanical Response of a Single Carbonate Fracture

Please fill in your author name(s) and company affiliation.

Given Name	Surname	Company
Alejandro	Cardona	King Abdullah University of Science and Technology
Thomas	Finkbeiner	King Abdullah University of Science and Technology
Mohammed S.	Bin Gubair	Saudi Aramco
Juan Carlos	Santamarina	King Abdullah University of Science and Technology

Abstract

Objectives/Scope: Fractures control the hydro-mechanical behavior of rocks (i.e., geo-plumbing). While the rock matrix is responsible for fluid storage, the presence of fractures can provide preferential flow paths but the fracture aperture would be sensitive to effective stresses. Thus, there is an inherent coupling between the hydro-mechanical behavior of natural fractures and changes in the effective stress associated with pore pressure. This study combines these effects with fracture topography and explores fracture transmissivity evolution using experiments on carbonate rocks.

Methods, Procedures, Process: We designed and built a self-reacting torsional shear device to simultaneously monitor fluid pressures and applied stresses. This novel design simplifies the control of fluid flow (i.e., unjacketed specimens) under radial conditions, has precise control of boundary conditions, and ensures constant shear stress throughout the fracture. We tested two carbonate rocks with a matrix permeability less than 0.1 mD. Fractures govern the fluid flow in these specimens. Furthermore, fracture topography data obtained with an optical profilometer help to identify salient fracture aperture variations.

Results, Observations, Conclusions: Fracture transmissivity shows a dual power-law behavior when subjected to normal stress. This reduction is up to four orders of magnitude at 11 MPa of normal load. The yield stress of the asperities indicates the transition between the two regimes. Whereas fracture transmissivity is highly sensitive to changes in normal stress, mechanical deformation may localize and hinder transmissivity reduction. Fracture topography becomes less relevant at high normal stresses but controls flow evolution during shear. The ratio between shear displacement and characteristic length of the asperities combined with the normal stress control the dilative tendency. Our experimental results further show transmissivity changes of less than one order of magnitude with shear. However, the published literature indicates transmissivity variations of up to five orders of magnitude. The low roughness of the tested specimens with a peak-to-valley distance of 20 µm for the smooth fracture and 50 µm for the rough fracture, may provide an explanation for these contradictory results. Additional

tests using acidified fluids illustrate that fractures that experience mineral dissolution result in an increment of the transmissivity. A larger fracture aperture and an enhancement of the connectivity clarify these observations.

Novel/Additive Information: This research builds on physical analyses towards a more predictive fracture transmissivity model as a function of changes in stress and roughness. The proposed analysis reduces the uncertainty of simulation models in fractured carbonate reservoirs and can be up-scaled for implementation into advanced reservoir simulators.