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The propagation of fractures in finely-layered reservoir rocks

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on the pressure and temperature conditions those fractures are formed and on the rock-mechanical properties of the rocks. In addition to these parameters, the complexity or heterogeneity of the material may also play a controlling role. Layering of the material in which each layer has its own mechanical characteristics complicates fracture growth. Fracture growth then depends on 1) difference in the mechanical properties of the formations on either side of the interface; (2) changes in horizontal stress across the interface; (3) shear strength of the interface.

This research examines the influence of rock-mechanical properties on fracture characteristics in layered rocks. Rock-mechanical laboratory experiments have been performed on dry two-layered and three-layered samples with unbounded interfaces, including layers of shale and sandstone, or granite and sandstone, in order to investigate the rock mechanical behaviour of the layered material and fracture propagation behaviour. Unconfined compression tests have been conducted to obtain rock-mechanical properties, including rock strength, Young's modulus, and Poisson's ratio. Fracture characterization, including fracture initiation, propagation, aperture, and interaction between the multiple layers, was performed using X-ray micro-computed tomography scans.

The results show that the variability in rock-mechanical properties influences the fracture behaviour in a layered reservoir. Predictions of the rock-mechanical properties of a layered material can be made based on the rock-mechanical properties of the individual layers. The elastic properties, including Young's modulus and Poisson's ratio, in layered materials can be described using Reuss-bound averaging of each individual layer. The strength, however, cannot be averaged. Fracture initiation is highly dependent on the rock strength: fractures initiate at the failure point of the weakest layer, whereas they do propagate at low average stress levels through stronger layers due to local stress amplification at the fracture tip. Fractures thus can propagate easily through strong layers that were expected to stop the fracture propagation. This may have important positive implications for oil and gas production of layered reservoirs but also very negative implications for e.g. seal integrity.