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A methodology for assessing the roughness and the hydraulic aperture in open fractures integrating photogrammetry and computational fluid dynamics

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Fractures play a critical role in governing flow paths for geofluids, such as groundwater, and hydrocarbons in reservoir rocks. The analysis and modelling of fracture characteristics and distributions are useful tools in reservoir quality characterization and predicting fluid behavior during production. Fluid flow through a single open fracture has been traditionally described by the cubic law, which is derived from the Navier-Stokes equation for the flow of an incompressible fluid between two smooth-parallel plates. Thus, the permeability of a single fracture depends only on a theoretical aperture value, the so-called hydraulic, which differs from the mechanical aperture (the measure of separation between the joint wall surfaces). Numerous works have included a friction factor in the permeability equation of individual fractures or derived a hydraulic aperture based on the fracture walls roughness. Despite these considerations, fracture aperture and the surface roughness remain among the most imprecisely evaluated fracture property in reservoir characterization. In this work, a new methodology for quantitatively assessing the highly detailed fracture wall surface topography and its control of permeability and hydraulic aperture of single fractures is presented. The methodology consists on combining Structure from Motion macro-photogrammetry, performed in situ on outcrop fracture surfaces or in laboratory facilities, and flow simulations using the lattice-Boltzmann method. To widen the results, this method is applied to fracture walls associated with other carbonate and clastic reservoir rock analog facies. Similarly, different mechanical aperture and displacement scenarios of the fracture walls are assessed in the simulations to evaluate their control of permeability.