3D Simulation of Fracture Propagation in Complex Reservoirs Rocks at Microscale

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The hydraulic fracturing (HF) is one of the most commonly used methods for improving oil recovery. Improvement of HF efficiency requires the generation of an extensive network of secondary (non-main) fractures in the reservoir rock. This work aims to study the fracture propagation at the microscale for determining the optimal stress-strain states sustaining the most extensive network of secondary fractures. The solution accounts for rock microstructure at various scales, elastic strength parameters and elastic-plastic type of rock behavior during fracture propagation. The object of investigation is Berezov formation that features low permeability (< 1 mD) and pore dimensions down to tens of nanometers. Microstructural characterization employed computed tomography (CT) before and after geomechanical tests, quantitative evaluation of minerals by scanning electron microscopy (QEMSCAN) and energy dispersive spectroscopy. Geomechanical characterization included multi-stage compressive strength tests, Brazilian tensile strength testing. Data processing included the segmentation of micro-CT data, the 2D-QEMSCAN to 3D-micro-CT registration. For the digital rock model, the preparation we built the mesh, then populated the model with mechanical properties, defined the contact behavior between mineral grains and set boundary conditions. Using an advanced commercial mechanical simulator, we modeled fracture propagation at the microscale, obtained the simulations of fracture initiation and propagation in a 3D-homogeneous porous matrix, 2D stress-strain state of the heterogeneous material with nine minerals and fracture evolution through intergranular contacts. We found the appearance of a plasticity region in the heterogeneous matrix associated with fracture propagation. The research results allow improving the efficiency of HF operations at unconventional reservoirs and increasing production from isolated pore systems by creating an extensive secondary-fracture network.