Influence of injection parameters on the dynamics of Hydraulic Fracturing monitored by Acoustic Emission

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Understanding the processes of Hydraulic Fracturing (HF) initiation and propagation in different types of rocks is important for the design and optimization of HF during the exploitation of underground resources. The main goals were to study the dynamics of the process of hydraulic fracture growth and possible optimization of HF technology for both homogeneous and heterogeneous rocks. Laboratory experiments on HF with different injection parameters were carried out on natural limestone, dolomite and shale specimens. The dynamics of HF process was monitored by Acoustic Emission (AE) technique, on the analogy of induced microseismicity monitoring of HF in the field conditions. The shape of created HF and the size of leak-off zone were analyzed by X-Ray CT scanning technique after the testing.

Experiments on dolomite were conducted using fluids with different viscosities (1000-10000 cP) injected into the rock with a rate of 0.5 ml/min. In case of low viscosity, we observed low AE activity. After the test, the sample was cut in several pieces transverse to the expected fracture plane. We have found that HF has initiated, but did not reach the sample boundaries and leak-off was significant. The ten times increase of fluid viscosity resulted in significantly increased AE activity, smaller size of leak-off zone and higher breakdown pressure (21.8 against 18.7 MPa). The post-test 3D shape of HF surface obtained by X-Ray CT closely correlates with 3D shape of localized AE events, confirming that the fracture propagated in the direction of maximal stress, as expected. It means that viscosity of fracturing fluid had a significant effect on fracturing breakdown pressure and fracture behavior.

The influence of different rock types on hydraulic fracturing was studied with dolomite, limestone and shale samples. In case of dolomite and shale, sufficient number of Acoustic Emission events were recorded, which allowed tracing the direction and dynamics of fracture propagation. However, for the limestone, a very small number of AE events were localized with the same parameters of injected fluid. Comparison of dolomite and shale HFIs shows that the crack in the shale had a more complex shape, deviating from the maximal stress direction, which was explained by rock heterogeneity, by the presence of natural cracks and inclined planes of weakness. It led us to conclusion that the rock fabric plays an important role in the behavior of hydraulic fracture in heterogeneous rock.