Laboratory investigation of fracture propagation by hydraulic fracturing under triaxial stress

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A laboratory-scale hydraulic fracturing test was conducted to investigate the characteristics of fracture development under variable conditions of differential stress and injection fluid viscosities. The breakdown pressure measured was identical to that calculated theoretically when the viscosity was 1 cSt; however, the breakdown pressures increased exponentially as the injection fluid viscosities increased. A slight difference in the rate of breakdown pressure increase during the experiment was observed in the 8 MPa case compared with the 3 MPa case.

Fracture development was controlled by the magnitude of differential stress. When the differential stress that is the difference between the maximum and the minimum principal stresses was small (3 MPa), the fracture propagation direction deviated from the maximum principal stress direction and multiple fractures were generated. In contrast, when differential stress was large (8 MPa), a single fracture propagated parallel to the maximum principal stress direction, as predicted by the elastic modelling of hydraulic fracturing. Fracture development in the 3 and 8 MPa cases was analyzed using AE signals, yielding results similar to those observed visually after the experiments. The fracture locations in the 3 MPa case were distributed more widely than those in the 8 MPa case. The results indicate that horizontal drilling for shale gas development should be oriented to ensure that the differential stress across the formation is small. In addition, low-viscosity injection fluid should be used to maximize the hydraulic fracturing of shale with a low breakdown pressure.