Shale Rheology and Retained Fracture Conductivity

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The effective exploitation of most shale petroleum reservoirs is generally considered to be reliant on the creation of economically productive fractures within the low permeability shale matrix. Hydraulic fracture stimulation is the most commonly attempted method of achieving this, and the creation of effectively propped fracture surface area is a key component of doing this successfully. Although field evidence is limited it is generally acknowledged that many such hydraulic fracture treatments result in significant fracture area that is minimally propped (monolayer of proppant), partially propped or not propped at all and yet is in hydraulic communication with the wellbore. Many factors may contribute to the reduction of this initial fracture conductivity and we will present some work related to retained fracture conductivity from the perspective of rock rheology. Rock mechanical testing was performed on core samples from the Duvernay Shale from the Western Canadian Sedimentary Basin and the Wolfcamp Shale from the Midland Permian Basin. The stress and time-dependent mechanical properties of these shales were determined and are described in relation to the petrophysical composition and fabric of the reservoir interval. Of note, the time-dependent deformation of some producing shales is on the same order as the elastic deformation. Appropriate creep deformation models were built to describe this behavior and to improve the overall constitutive model of shale response to stress changes through time. Proppant embedment and fracture conductivity measurements were made in these same shales over a range of stress and time paths. The constitutive models are shown to be able to predict the reduction in conductivity due to embedment. Numerical models are used to demonstrate the impact of reservoir stress path on damage mechanisms that act to reduce initial fracture conductivity. The implications for proppant selection and managed pressure drawdown are discussed.