2011 CSPG CSEG CWLS Convention

Using Geomechanics to Characterize Natural Fracture Attributes in Shales and to Predict their Influence on Hydraulic Fracturing

Jon E. Olson, Petroleum and Geosystems Engineering, The University of Texas at Austin
jolson@mail.utexas.edu, 512-471-7375

The attributes of natural fracture systems can be related to the geomechanical properties of rocks and the geologic loading history. Diagenetic history also plays a strong role in the fluid carrying capacity of the natural fracture system. Natural fracture height containment is strongly influenced by the elastic properties of the rock that control stresses induced by horizontal tectonic strains. Fracture spacing and length distributions can be predicted using fractured layer thickness and the subcritical crack index (a fracture mechanics property of the rock). Spacing scales roughly with layer thickness, but significant variation in the degree of clustering can be related to the magnitude of the subcritical index, which is not only a function of rock type but also fluid environment. Shales tend to have high values of subcritical index when tested in air or hydrocarbon, which should result in a stronger degree of clustering. However, when saturated with brine, the subcritical index in shale can be much lower and may result in fracture spacing much closer than layer thickness. The layer thickness and subcritical parameters also influence fracture length distribution and fracture pattern geometry. Modeling results show that thinly bedded sequences have fundamentally different fracture patterns than thick beds that can result in very different permeability results. Finally, subsequent to or simultaneous with mechanical opening, there will be diagenetic precipitation in the fractures. Whether the fractures are completely or partially mineralized will influence flow properties and their sensitivity to stress. The degree of cementation and the cement strength also play an important role in how hydraulic fractures interact with the natural fractures. The hydraulic fracture can reopen a natural fracture even if the fracture is completely filled with cement when the fracture cement is weaker than the formation around it. The likelihood of hydraulic fracturing crossing versus diversion can be predicted based on relative fracture strengths of the formation versus fracture cement and the approach angle of the fractures.