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Simulating Natural Hydraulic Fractures in Muddy Rocks—Implications for Seal Capacity and Primary Migration

Work by Terry Engelder (Penn State Univ), on the Devonian shales and siltstones in western New York State, has led to the creation of a conceptual model to explain the pervasive fracturing observed. This model suggests that the fractures are joints, with plume markings indicating cyclical growth/arrest propagation. The process model suggests that when the pore fluid (gas) reaches a certain pressure (determined from fracture mechanics theory), the joints propagate. The pore pressure falls DURING a crack growth event, because growth is faster than the gas can re-supply (in a "closed" system, P1V1=P2V2), leading to a cessation of growth, then subsequent recovery to begin a new cycle. We have explored this model using a standard reservor simulator constrained by the geomechanics of the fracture process. Using petrophysical parameters representative of shales and siltstones, the simulations develop cyclical natural hydraulic fractures like those observed in the outcrop examples. Each fracture propagates to a "large" size (10-100 m lengths) over a time period on the order of one day. The volume of siltstone affected by the pressure drawdown is quite small, extending less than 10 cm normal to the fracture plane. Such fractures, initiated at random points through a rock volume, would grow until they "filled" the volume at a final spacing of about 10-20 cm, which is the same as observed in the field. The geologically "instantaneous" development of such a pervasive fracture system has important implications for sealing, migration, and for basin-centered gas reservoirs.