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Evaluation of Conventional Stimulation Techniques in Mannville CBM Reservoirs

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Coalbed methane (CBM) is predominantly present as adsorbed gas into the solid matrix of coal. Coal has some unique characteristics which make it behave differently than other kinds of reservoir rocks. The deposition and coalification process results in coals being inherently fractured by endogenous shrinkage forces (orthogonal fractures or cleats), and exogenous structural forces (larger aperture fractures or mega cleats). A coal matrix itself generally has very low permeability, with cleats being the primary source of permeability. And cleat permeability is strongly dependent on the orientation and magnitude of horizontal stresses. Mechanically, coal also has a higher Poisson's ratio and a lower Young's modulus than the surrounding clastic rocks. This leads to higher horizontal stresses and fracture gradients, making it difficult to initiate a new fracture and to contain it within the coal seam. Furthermore, cleats and overprinting structural fractures in coal result in complex fracture networks created during the hydraulic fracturing process (versus simple bi-wing fractures) that are difficult to predict or model.

For economic production from CBM reservoirs, it is necessary to create sufficient surface area in contact with the reservoir via hydraulic fracturing or any other stimulation technique. As the cleats are naturally occurring weak interfaces, they provide a pre-existing network of planes of weakness that facilitate the generation of surface area, during hydraulic fracturing and, under favorable conditions, result in a considerable increase in fracture area per unit reservoir volume. Most commonly, however, limited surface area is generated due to hydraulic energy dissipation along an individual plane of weakness which, in the absence of proppant, is closed due to the lithostatic stresses acting on them.

Historically, a number of stimulation techniques have been employed in CBM wells, e.g. coal cavitation, direct or indirect propped hydraulic fracturing, HiEnergy Pulse Frac, etc. One of the primary difficulties in the conventional CBM stimulation is connecting hydraulic fractures with the existing face/butt cleats and mega cleat network. When a hydraulic fracture intersects a cleat it will either overcome and pass through the cleat or alter its course, follow and dilate the cleat. Both of these situations could be advantageous depending on how far the hydraulic fracture is able to connect the cleat network. Field data indicate that if the contrast in horizontal stresses is small then the fracture will more or less follow the cleat network and dilate the cleat apertures. However, if the contrast is large, depending on the cleat orientation, hydraulic fracture will overcome the cleat and continue farther from the near-wellbore. This can potentially create fracture(s) which propagate upwards/downwards and provide a connectivity path between coal reservoir and adjacent formations thus leading to water production risk if formation below or above is wet. When the face cleats and mega cleats are near parallel to the maximum horizontal stress, hydraulic fractures propagate parallel to cleats, reducing the chances of a proper connection with the cleat network, leading to lower production rates. Because of these challenges and unique characteristics of coal, CBM reservoirs demand novel approaches in completion and stimulation processes to enable optimized economic production.

In this paper, authors (i) review conventional stimulation techniques normally employed in CBM, (ii) evaluate these techniques based on production data from more than 60 wells completed in the Mikwan Mannville CBM located in the East Central Alberta, (iii) identify factors that can inhibit stimulation effects in these techniques based on the field data and observations and (iv) offer solutions and alternative techniques that can potentially increase efficiency in coal stimulation.