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Research on the Vertical Fracture Propagation Behavior of Deep Offshore Sandstone Reservoirs

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ABSTRACT

The mechanism of vertical extension in high-volume hydraulic fracturing is of significant importance for the volumetric transformation of low-permeability reservoirs in deep offshore sandstone formations. The complexity of fracture propagation behavior is influenced by the characteristics of discontinuous thin layers in the vertical plane. However, the mechanisms and influencing factors of fracture extension in the vertical direction during high-volume hydraulic fracturing remain unclear. This study integrates true triaxial hydraulic fracturing experiments with acoustic emission (AE) monitoring, employing a nonlinear finite element method to establish a multi-thin interlayer fracturing model based on seepage-stress-damage coupling. It investigates the effects of various factors, including the stress field of the reservoir, fracturing fluid viscosity, and the characteristics of thin interlayers, on vertical fracture propagation. The results indicate that fracturing from high-stress regions to low-stress regions promotes vertical fracture extension. A vertical stress difference greater than 5 MPa favors the longitudinal expansion of hydraulic fractures, while a horizontal stress difference exceeding 3 MPa results in simpler fracture morphologies. Under conditions of high volume and viscosity, the infiltration of fracturing fluid into the matrix is limited, leading to greater elastic energy accumulation at the fracture tips, which facilitates interlayer penetration and extension. When the thickness of thin interlayers exceeds 5 m, the ability to penetrate layers diminishes, and this ability is contingent upon interface strength and matrix strength. These findings provide valuable theoretical guidance for vertical fracture extension in high-volume hydraulic fracturing in deep offshore sandstone reservoirs.

KEYWORDS

Hydraulie fracturing; acoustic emission; fracture extension; deep offshore sandstone reservoirs

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