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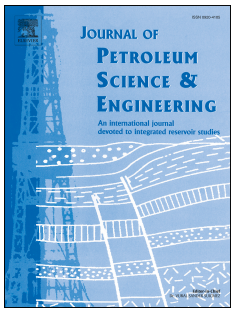

Interaction between cemented natural fractures and hydraulic fractures assessed by experiments and numerical simulations

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Interaction between Cemented Natural Fractures and Hydraulic Fractures Assessed by Experiments and Numerical Simulations

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Abstract

Microseismic events suggest that a complicated fracture network develops during hydraulic fracturing treatment in many naturally fractured unconventional reservoirs. One reason for the complexity is the deformation along weak planes such as faults and cemented natural fractures. The interaction of cemented natural fractures with hydraulic fractures generated as part of reservoir stimulation may impede or terminate hydraulic fracture propagation, which depends on several factors such as interfacial bond strength between the cemented natural fractures and the reservoir rock. Most previous studies treat natural fractures as interfaces without considering their thickness. In this study, the semi−circular bend (SCB) tests for specimens with heterogeneity are used to study the fracture−fracture interactions, because the tensile fracture in the SCB test is analogous to the induced hydraulic fracture. With simple experimental setup and good repeatability, the SCB test results provide insights into real hydraulic fracture propagation behavior in naturally fractured reservoirs. We analyze the effects of natural fracture thickness and rock−cement interfacial bond strength, which are not commonly considered. Results show that hydraulic fracture crossing/diverting behavior depends on the approach angle, the rock−cement interfacial bond strength, and the thickness of natural fracture. Results also imply that as hydraulic fractures approach cemented natural fractures, the hydraulic fracture near–tip stress state is influenced by the tensile and shear strength of the rock−cement interface. In the SCB test, the sample geometry induces shearing along the cemented natural fracture−rock interface, analogous to a frictionally slipping interface in the subsurface. Depending on the frictional strength and the approach angle, the interface may crack apart, and attract a propagating fracture.

Keywords

Hydraulic fracturing
Cemented natural fractures
Fracture–fracture interaction
Semi−circular bend experiment

1. Introduction

Natural fractures exert a fundamental control on hydrocarbon recovery from low−permeability unconventional reservoirs such as shale formations. For the purpose of maximizing hydrocarbon production, hydraulic fracturing is generally used to create long and penetrating fractures, increasing the stimulated rock volume by connecting natural fractures (Huang et al., 2014). Understanding the interaction between natural fractures and hydraulic fractures provides insight into successful planning of the well trajectory and stimulation design through producing formations.