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Spatiotemporal Evolution Characteristics of Internal Stress in Granite Under Excitation Pressure (Postprint)

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Abstract

Hydraulic fracturing technology is a key technology in geothermal resource extraction, which achieves the heat exchange requirements in engineering by fracturing the reservoir. However, during the injection fracturing process, the pressure of the fracturing fluid (injection pressure) acts on the wellbore and causes stress changes in the reservoir, thereby making the fracture propagation mechanism more complex. In this study, hydraulic fracturing experiments under different injection rates, injection frequencies, and in-situ stresses were conducted using a self-developed true triaxial hydraulic fracturing system with strain monitoring. A stress response model was established based on the propagation mechanism of injection pressure within granite, and based on this model, the spatiotemporal evolution characteristics of stress during the hydraulic fracturing process were analyzed stage by stage, with particular emphasis on investigating the variation law of the potential fracture initiation point B0 location. The following conclusions were drawn: (1) The stress changes inside the rock sample before fracture initiation can be divided into three stages: confining pressure only, circumferential tensile stress emergence, and maximum circumferential tensile stress. (2) After the emergence of circumferential tensile stress, it decreases more significantly within the near-wellbore region and attenuates rapidly with radial distance. (3) When the injection pressure reaches its peak, an approximately elliptical tensile stress region appears around the wellbore with the maximum principal stress direction as its long axis. The circumferential tensile stress is maximum at the B0 location, and it first increases and then decreases with injection frequency.

Full Text

Preamble

Title: Spatial-temporal Evolution Characteristics of Stress in Granite Under Stimulated Pressure

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Abstract

Hydraulic fracturing is a critical technology for geothermal resource extraction, wherein reservoirs are fractured to meet heat exchange requirements in engineering applications. However, during injection fracturing, the pressure of fracturing fluid (stimulated pressure) acts on the wellbore and induces stress changes within the reservoir, thereby complicating fracture propagation mechanisms.

This study employs a self-developed true triaxial hydraulic fracturing system with strain monitoring to conduct hydraulic fracturing experiments under varying injection rates, injection frequencies, and in-situ stress conditions. Based on the propagation mechanism of stimulated pressure within granite, a stress response model was established to analyze the spatio-temporal evolution characteristics of stress during hydraulic fracturing, with particular emphasis on investigating the variation patterns of the potential fracture initiation point B0.

The following conclusions were drawn: (1) Prior to fracture initiation, internal stress changes in rock samples progress through three distinct stages: confining pressure only, emergence of circumferential tensile stress, and development of maximum circumferential tensile stress. (2) Following the emergence of circumferential tensile stress, a significant reduction occurs within the near-wellbore region, with rapid attenuation as radial distance increases. (3) When stimulated pressure reaches its peak, an approximately elliptical tensile stress zone develops around the wellbore, with the maximum principal stress direction serving as the long axis. The circumferential tensile stress is maximized at the B0 location and exhibits a trend of initial increase followed by decrease with increasing injection frequency.

Keywords: stimulated pressure; stress response model; circumferential tensile stress; spatio-temporal evolution

Note: Figure translations are in progress. See original paper for figures.

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