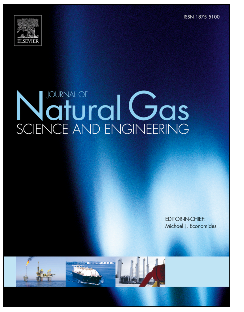

Experimental study of supercritical CO_2 fracturing on initiation pressure and fracture propagation in shale under different triaxial stress conditions

Yongdong Jiang, Chao Qin, Zhipeng Kang, Junping Zhou, Ye Li, Hui Liu, Xiao Song

PII: S1875-5100(18)30178-1

DOI: 10.1016/j.jngse.2018.04.022

Reference: JNGSE 2544

To appear in: *Journal of Natural Gas Science and Engineering*

Received Date: 13 June 2017

Revised Date: 19 April 2018

Accepted Date: 22 April 2018

Experimental study of supercritical CO_2 fracturing on initiation pressure and fracture propagation in shale under different triaxial stress conditions

Yongdong Jiang*, Chao Qin, Zhipeng Kang, Junping Zhou, Ye Li, Hui Liu, Xiao Song

(State Key Laboratory of Coal Mine Disaster Dynamics and Control, Chongqing University, Chongqing 400044, China)

Abstract: Supercritical carbon dioxide (SC-CO_2) fracturing technique used in the development of shale gas has attracted increasing attention in the past decades. Using a self-developed physical simulation system equipped with acoustic emission (AE) and computed tomography (CT) system, the fracture initiation pressure (FIP) and fracture propagation mechanism of shale in the process of SC-CO_2 fracturing was invested. The results show that the FIP for the shale without pre-existing fractures obtained from experiment is consistent with the theoretical values under different triaxial stress conditions, indicating that the theoretical calculation for FIP is feasible. The FIP increased gradually with increasing in situ stress for the shale without pre-existing fractures. The pre-existing fractures will affect the FIP and the fracture propagation direction in the shale. AE signals are obviously observed in the fracture initiation and the fracture propagation stages. In addition, the hit, energy, and amplitude are increased stepwise with increasing fracturing time. In the triaxial stress state, the initiation position and the propagation direction of cracks are random in the process of the SC-CO_2 fracturing of shale and are along the direction of weak structural planes or pre-existing fractures. The SC-CO_2 fracturing technique integrated with AE monitoring and CT scanning can be used to analyse the crack initiation position, the direction and sequence of crack propagation, and the number of the fracturing-generated cracks in shale. This research lays a foundation for SC-CO_2 fracturing of shale in the Longmaxi formation in the Sichuan Basin.

Key words: Supercritical carbon dioxide; Shale; AE monitoring; CT scanning; Fracture

1 Introduction

Shale gas has attracted much attention in recent years as an unconventional natural gas (Jiang et al., 2016; Yin et al., 2017). The total amount of global shale gas resources is estimated to be 456×10^{12} m^3, accounting for 50% of three unconventional natural gas resources (Jiang et al., 2016; Yang et al., 2014; Yang et al., 2017). The shale gas resources in China are very abundant, the technically recoverable reserves of shale gas resources in china is estimated to be 25×10^{12} m^3 (Guo et al., 2016; Yang et al., 2014). In 2015, the shale gas production was 45×10^8 m^3. The shale gas production planned for 2020 will be more than 300×10^8 m^3. Shale gas reservoirs show the characteristics of low porosity, low permeability, low pressure, and high clay content. Therefore, the reservoir stimulation during shale gas exploitation is extremely necessary (Gregory et al., 2011; Liu et al., 2017; Zhang et al., 2017; Zhou et al., 2016). Currently, the main techniques for increasing the permeability of shale formation are horizontal wells and hydraulic fracturing. However, SC-CO_2 fracturing, as a promising technology, has been attracted more attentions recently due to its potential to enhance fracturing and shale gas recovery (Biryukov and Kuchuk, 2015; Cao et al., 2017; Jarboe et al., 2015; Liu et al., 2016; Middleton et al., 2015; Qin et al., 2017; Shi et al., 2016; Yin et al., 2016; Zhao et al., 2017). Compared to hydraulic fracturing, the advantages of SC-CO_2 fracturing are as follows (Conde-Hernandez et al., 2017; Duan et al., 2016; Hossain et al., 2016; Rudzinski and Aminabhavi, 2000; Yin et al., 2017; Zhang et al., 2017): 1) Generation of fracture network easily due to its low viscosity, low initiation pressure; 2) Reduction of formation damage as its high flowback rate and avoid the hydration swelling of clay minerals; 3) Displacement of pre-adsorbed CH_4 and sequestration of CO_2 simultaneously; 4) Saving water resources; 5) minimize environmental pollution.

* Corresponding author. Tel.: +86 13594096490.
E-mail address: jiangyd1015@163.com.