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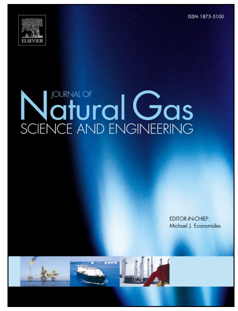

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Understanding Natural Fractures and Stress as Controls to Hydraulic Fracture Geometry in Depleted Reservoirs

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Abstract
Pressure changes in the reservoir due to injection or production, lead to anisotropic changes in the magnitude and orientation of the stresses in the reservoir. The characteristics of the modified stress field can potentially lead to asymmetric fracture growth in infill wells stimulated by hydraulic fracturing, which in turn could potentially cause a detrimental interference between wells. The final geometry of the hydraulic fractures, however, will depend on the relative contributions of several other variables and not on changes in stress alone. Therefore, for the planning and optimization of infill wells, the interplay among these variables must be accounted for. In this paper we study via numerical simulations, the relative weight of rock fabric and depletion-induced stress in relation to the geometry and propagation of hydraulic fractures near a producing well. Our results indicate that the presence of a dense network of natural fractures can overide the effect of depletion-induced stress, and limit the asymmetric growth of the fractures.

1. Introduction

The development of oil and gas from tight reservoirs has progressed quickly in recent years due to multistage hydraulic fracturing of horizontal wells. In these tight reservoirs, the drainage area per well is relatively small as compared with conventional reservoirs, so more wells are needed to produce hydrocarbons at a reasonable rate. Drilling and stimulating of infill wells is a current practice to enhance production. Yet, pressure changes resulting from production of neighbouring wells, may to anisotropic changes in the magnitude and orientation of the stress in the reservoir and this can negatively affect the outcome of the hydraulic fracturing of the infill wells. As an example, (Gupta, et al., 2012) pointed out the potential reorientation of the hydraulic fractures parallel to the wells due to stress rotations. Previous work also linked the development of asymmetric fractures to destructive well interference and production decline; see for instance (Mukherjee, Poe, Heidt, Watson, & Barree, 2000; Ajani & Kelkar, 2012; Kurtoglu & Salman, 2015) and (Marongiu-Porcu, Lee, Shan, & Morales, 2015). One could expect, however, that the degree up to which depletion-induced stress would affect infill wells would depend on how strongly depletion modifies the original stress field, and on the relative weight of stress in relation to fracture propagation as compared to other variables such as the characteristics of the rock, production time and distance among wells. The interplay among these variables must be understood to fully plan and optimize infill wells. This paper presents a numerical study on the potential scenarios in which asymmetric fractures can develop. The relative weight of two variables is considered: one, the depletion-induced stress changes and two, the rock fabric represented here by a network of natural fractures.

From a theoretical standpoint, asymmetric fracture growth in infill wells can be predicted from analytical models based on linear poroelasticity. Here, depletion-induced stress changes are usually quantified in terms of the stress path coefficients $\gamma_V, \gamma_h, \gamma_H$ defined as:

$$\gamma_h = \Delta\sigma_h / \Delta P \tag{1a}$$

$$\gamma_H = \Delta\sigma_H / \Delta P \tag{1b}$$

$$\gamma_V = \Delta\sigma_V / \Delta P \tag{1c}$$

where $\Delta\sigma_h, \Delta\sigma_H$ are respectively the changes in the minimum and maximum principal horizontal stress components, ΔP is the change in pressure and $\Delta\sigma_V$ is the change of the vertical stress. The value of γ_V is usually called *arching coefficient*. The *stress path* coefficients depend on the contrast in the mechanical properties of the reservoir and its surroundings, the reservoir shape and depth. Analytical models based on linear poroelasticity presented by (Segalla & Fitzgerald, 1998; Safari, et al., 2013) among others (Eshelby, 1957; Addis, 1997; Holt, Flornes, & Li, 2004; Segura, et al., 2011) predict a linear change in the horizontal stress with pressure depletion:

$$\gamma_h = \gamma_H = \alpha \xi(e) \omega(E, \nu) \tag{2}$$

where α is the Biot's coefficient, $\xi(e)$ is a function of the thickness to length ratio of the reservoir, and ω is a function of the Young's modulus E and Poisson's ratio ν of the rock. In these models it is assumed that the geological stresses do not change with depletion, that the pressure depletion is uniform and that the reservoir reacts elastically to any changes in

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