Paper Number: 197

In-situ Fracturing Characterization of Tight Sand: Insight for Reservoir Stimulation

WU, S.T., ZHU R.K., CUI J.W. and Yang, Z.
Research Institute of Petroleum Exploration and Development, PetroChina, No. 20 Xueyuan Rd., Beijing;
wust@petrochina.com.cn

Nowadays, hydro-fracturing is critical for the effective development of unconventional tight oil and gas (Zou et al., 2013). Scholars and engineers have carried out abundant researches on hydro-fracturing and have concluded several key factors on the fracture generation, including subsurface stress & pressure, rock mechanics and fracturing fluid (Rawing et al., 2002; Zhong et al., 2015; Qu et al., 2016). However, there are still some uncertainties about the distribution of newly-generated subsurface fractures. Micro-seismic monitoring are not adequate to provide the high resolution picture of hydraulic fractures growth, and the noise can have great effect on the interpretation, which may result in stimulation failure. Thus, it is urgently needed to carry out precise fracture growth characterization to understand the special distribution of fractures and to provide reference for on-site hydraulic fracturing.

The sample is the tight fine-grained arkose from the Upper Triassic Yanchang Formation in the Ordos Basin, which is the most successful tight oil play in China. Micro-CT is used to scan the tight sand samples at different pressures to simulate the whole process of hydraulic fracturing. The pixel resolution is 2.75μm and the sample is a pillar with diameter & length of 3mm. The porosity and permeability is 7.8% and 0.09mD, respectively. The pressure increases along the axial direction from 0.6MPa to 4.0MPa, 8.0MPa, 12MPa and 14MPa finally.

The new observations and results are as follows

(1) The growth of new fractures is positively related to pressures. The initial fracture is observed at the pressure around 8MPa, then it extends to form abundant secondary fractures, and finally forms complex and connected fracture network. The size of new fractures ranges from 3μm to 250μm.
(2) New fractures are developed along the pressuring direction, occurring along the boundary between silica minerals and cements (i.e., calcite, dolomite). Few fractures could cut through the silica minerals, such as quartzs and feldspars. No obvious connection between pre-existing pores and new fractures is observed.
(3) From 4.0MPa to 14MPa, the sample extends 0.05mm, 0.12mm, 0.18mm and 0.27mm, and the corresponding volume expansion is 3%, 8%, 12%, and 19%, respectively.

In this study, 3D models of fractures at different pressures are reconstructed by using CT in-situ segmentation, which can show the dynamic development of fractures directly. The results are helpful to understand the origin and controlling factors of new fractures, and can provide reference for on-site hydraulic fracturing.

References:

[1] Zou CN, (2012) ELSEVIER, 978-0-12-397162-3.
[2] Zhong JH, Liu SX, Ma YS, Yin CM, Liu CL, Li ZX, Liu X, and Li Y(2015) Petroleum Exploration and Development

42(2): 242-250
[3] Rawing GC, Baud P and Wong TF (2002) Journal of Geophysics Research 107(B10): 2234
[4] Qu GZ, Qu ZQ, HAZLETT RD, FREED D, MUSTAFAYEV R (2016) Petroleum Exploration and Development 43(1): 1-7