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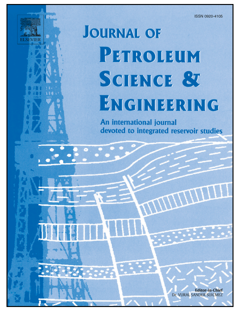

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LIDAR-based fracture characterization and controlling factors analysis: An outcrop case from Kuqa Depression, NW China

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Abstract

Fracture is of primary importance to the natural gas production capacity from many tight sandstone reservoirs in the Kuqa foreland basin, NW China, but the orientation, size and plane porosity of the fractures in the subsurface is difficult to measure directly. Terrestrial light detection and ranging (LIDAR) surveys can offer factual information of outcrop-based research efforts to characterize fracture development laws and controlling factors. In this paper, utilizing a multi-level covering, we obtain the three dimensional (3D) point cloud data from a LIDAR survey launched at a typical outcrop. Matching with high-resolution digital photos and artificial measured information, the 3-D positions of natural fractures are extracted strictly in the data volume section. Furthermore, the fracture and reservoir model can be founded based on the systematic sampling and laboratory analysis, while a variety of accurate facture parameters can be obtained. It is founded that three groups of shear fractures are mainly developed in two periods with large inclination, short trace length and small spacing of normal distribution. Its patterns has provided a literal distribution of penetrating fracture zone and interlayer fracture zone with a single and a double set of advantage orientation respectively. It turned out that the fracture development scale is controlled by lithology, layer thickness, maximum principle paleostress and rock composition with a good exponential relationship. Our work could provide a workflow linking outcrop fracture observations to the 3D model of subsurface fracture prediction and extend modeling capability in other outcrop studies.

Key Words: LIDAR, fracture, development characterization, controlling factors, Kuqa Depression

Recently, the deep oil and gas reservoirs of more than 4500m depth have become a hot exploration field. Their physical properties are generally poor due to the strong digenesis and the fractures play a key role to improve the reservoir quality (Jia and Pang, 2015). A series of fracture distribution and prediction models have been established by various methods of artificial outcrop observation, core analysis, log interpretation and rock mechanics simulation (Zou et al., 2013; Zhang and Jin, 2003; Gao and Xie, 2007; Hencher, 2013; Watkins et al., 2015), where the outcrop is the most intuitive place for a comprehensive observation of the fracture distribution rules and the correlation between different fracture groups, while it has got more attention increasingly because it can provide more holistic and visual geological bodies (Ding et al., 2015). Olariu (2008) and Wilson (2011) have tried to use three dimensional (3D) laser scanning technology to obtain the fracture information on the outcrop for reconstructing the subsurface discrete fracture network model which can make up the shortage of the traditional manual measurement with a great error to provide more realistic geological message and it has been applied into the research of down hole fluid simulation successfully.

Quantitative study on the control factors of reservoir fractures is an important basis for accurately predicting fractures distribution, which is of great practical significance to guide the exploration and development of fractured oil and gas reservoirs (William, 1997; Gao et al., 2015). The development of structural fractures in a certain area is the result of rock deformation and rupture under the action of tectonic stress, and the rock properties of reservoirs are its material basis and internal factors (Zeng and Zhou, 2004). The tectonic stress field of the reservoirs includes the stress

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