True 3D Fracture Simulation with Geology-engineering Integration of Volume Modification in Jimsar Shale Oil

Kui Zhang¹, ⁵, Yang Xiao², ³, *, Leiming Cheng¹, Shouyu Liu², ³, Junchao Wang¹ and Mingqiang Xu⁴

¹ Engineering Technology Research Institute, Xinjiang Oilfield Company, PetroChina, Karamay, China
² School of Energy, Chengdu University of Technology, Chengdu, China
³ Chengdu Institute of Technology Sunshine Energy Technology Co., Ltd., Chengdu, China
⁴ Shale oil Project Management Department, Development Company, PetroChina
⁵ CNPC Engineering Technology R&D Company Limited, Beijing, China

*Corresponding author e-mail: zd_chlm@petrochina.com.cn

Abstract. The main characteristics of Jimsar shale oil reservoir are of complex structure, strong heterogeneity and great difficulty in fracturing. It is mainly produced by volume fracturing technology, which is easy to form complex fracture networks. At present, the design and parameter optimization of fracturing scheme are not targeted, and the true 3D fracture simulation with geology-engineering integration is particularly important. On the basis of 3D geological modeling, the 3D geo-mechanical parameter distribution is determined by seismic data, logging data, experimental data, etc to simulate the stress environment in which the overburden pressure, surrounding rock pressure and lower strata pressure. And the 3D geo-mechanical parameter model is established by combining simulated analysis of the stress. On the basis of geological model, geo-mechanical model and natural fracture model, the natural fractures and faults determined by seismic, logging or discrete fracture modeling are integrated into the geo-mechanical model to complete the true 3D simulation of artificial fracture network based on true 3D geo-mechanical model. This simulation is the practice and improvement of the geology-engineering integration of shale oil reservoirs volume modification technology in Jimsar, which will deepen the geological understanding and strengthens the engineering technology supporting, provides reference basis for the optimization design of fracturing process and the maximization of the volume, and finally realizes the efficient development of shale oil in Jimsar.

1. Introduction

Jimsar sag is a secondary tectonic unit deposited on the Middle Carboniferous fold basement with a dustpan-like sag high in the east and low in the west, and its peripheral boundary features are obvious and three sides are cut off by faults. In the West, the Xidi fault and Laozhuangwan fault are connected with the Beishantai hump. In the north, the Jimsar fault is adjacent to the Shaqi hump. In the south is
the Santai fault. The eastward direction is a gradual uplifting slope, which eventually transits to the Guxi hump. The center of the sag is located near the Xidi fault. Structural activity in the sag is relatively weak and Lucaogou Formation is lack of structural traps. Jimsar is a fault block oil reservoirs with natural fracture, complex lithology and strong heterogeneity. The Permian Lucaogou Formation reservoir in the Tiandian block belongs to medium-low porosity and ultra-low permeability reservoir. In the early stage, the effect of conventional acidizing and fracturing is not perfect in some of these wells, so the True 3D Fracture Simulation with Geology-engineering Integration technology can be used to solve the problems of low level of exploitation and unsatisfactory fracturing effect for fault block reservoirs.

The focal points and difficulty of the volume fracturing are complex fracture network and true 3D simulation, which determines the formulation of volume modification scheme and the optimization design of construction parameters, and is also a bottleneck restricting the development of volume fracturing technology [1]. At present, there is lack of commercial software at home and abroad which can simulate the fracture initiation and propagation in volume fracturing, especially starting from the establishment of geomechanical model, the true 3D fracture simulation of artificial fracture network is completed on the basis of regional stress field and local stress disturbance [2]. This paper realizes the simulation from the true 3D model of geomechanics to the true 3D fracture of volume reconstruction by combining the multi-methods and multi-disciplines of geomechanics modeling, regional stress simulation, weakness planes research and true 3D fracture simulation [3, 4].

2. Establishment of 3D Geomechanics Model for Fault Block Reservoir

In view of the above complex reservoir reconstruction problems, we adopt the geology-engineering integration, and the most important one is the establishment of 3D geomechanical model [5]. Using the traditional single well rock mechanics parameters and interpretation model of in-situ stress parameters to interpret single well logging data is far from meeting the needs of the field. Because of the unknown property of interwell reservoir, it is necessary to use the means of 3D modeling and 3D simulation to predict interwell rock mechanics parameters.

The foundation of 3D geomechanical model lies in the establishment of one-dimensional rock mechanics profile. By establishing gohfer parameter model and introducing gamma curve, self-potential curve and sound wave moveout curve, we can interpret dynamic rock mechanics parameters. Then, by means of rock mechanics experiment in Jimusar block, the three-layer dynamic and static fitting formula is explained in stratified section. Finally, the range of dynamic Young's modulus, Poisson's ratio and other mechanical parameters are fitted according to lithological changes, and a one-dimensional rock mechanics profile is established.

![Figure 1](image-url). Jimsar reservoir attribute model and rock mechanics parameter model.
According to the geological characteristics of Jimsar fault block reservoir, the structural model, attribute model and rock mechanics parameter model are established. Using the discrete element simulator visage, taking the reservoir as the elastic medium, adding the equivalent material of top strata, base and surrounding rock around it, and adding steel plates around it to eliminate the stress concentration, using the vector displacement field and continuous displacement compatibility equation, the pressure and temperature under the real reservoir conditions are given, and the in-situ stress is added in all directions to simulate the process of reservoir diagenesis. Through the convergence of the maximum unbalanced force to complete the stress simulation, finally get the stratum properties, in-situ stress and rock mechanics parameters which are closest to the real situation of the stratum.

In order to simulate the most reliable fractures, a 3D geo-mechanical model is established in real stratum, which solves the limitation of conventional fracturing based on interpretation parameters of single well logging curve and overcomes the problem of inhomogeneity of reservoir plane and vertical. The design idea is as follows:
Select one of the wells as the target well, establish the target model wellbore. The range and number of segments were set for cluster perforation. Based on the 3D geo-mechanical model, fracturing design was carried out, and the influencing factors of displacement, sand and net fluid were analyzed.

![3D Geomechanics model and fracture network simulation.](image)

**Figure 4.** 3D Geomechanics model and fracture network simulation.

The fracture volume is the most important parameter in network fracturing. By designing the different parameter, the simulation analysis shows that the optimal displacement is 12m³/min.

![Influence of displacement.](image)

**Figure 5.** Influence of displacement.

By optimizing the construction parameters, it provides the theoretical basis and foundation for the subsequent fracturing parameters of jimsar, and also provides the mentality for the integrated fracturing technology of geology-engineering integration, and guarantees the recovery efficiency and economic benefits of the target well area.

4. **Conclusion**
For the Jimsar fault block reservoir, the idea of geology-engineering integration is adopted. The full 3D network fracturing simulation based on the true 3D geo-mechanical model is more reliable, and the analysis of influencing factors can provide a theoretical basis for the construction parameters of fracturing Wells in the later stage.

When the hydraulic fracture encounters weak plane, it will extend along the weak plane under sufficient net pressure, and the most effective way to achieve sufficient net pressure is to increase the displacement.
Acknowledgments
This work was financially supported by the National Natural Science Foundation of China (No. 51504042, No.51604043); Subitem of National Science and Technology Major Project (2016ZX05048-001-04-LH); Key Project of Sichuan Provincial Education Department Foundation (18ZA0063).

References
[1] Yamamoto K, Shimamoto T, Maezumi S, Development of a True 3D Hydraulic Fracturing Simulator, J. Society of Petroleum Engineers, 1999.
[2] Zheng Peng, Numerical simulation of volumetric fracturing crack propagation in shale reservoirs, D. Xi'an Shiyou University, 2016.
[3] Peng Chunyao, Study on interference mechanism of hydraulic fracturing cracks and weak surface of rock mass in layered shale, J. Petroleum Drilling Technique, 2014(4): 32-36.
[4] Zhou Junjie, Summary of Research and Development of Hydraulic Fracturing 3D Model, J. Science and Technology Innovation Review, 2017, 14(08): 71+73.
[5] X.Weng, O. Kresse, C.Cohen, et al. Modeling of Hydraulic-Fracture-Network Propagation in a Naturally Fractured Formation, J. Society of Petroleum Engineers, 2011, 26(4): 368-380.