Scholars Bulletin
(A Multidisciplinary Journal)
An Official Publication of "Scholars Middle East Publishers",
Dubai, United Arab Emirates
Website: http://scholarsbulletin.com/

ISSN 2412-9771 (Print)
ISSN 2412-897X (Online)

Modeling Method of the Multi-Scale and Multiple Medium Unconventional Tight Oil-Reservoir: A Case Study of the Reservoir in Lucaogou Formation of Junggar Basin

He Wei[1], Ma Shizhong[1], Lang Juntian[2], Zhu Yu[2], Ni Bowen[2]
[1]Earth Science of Northeast Petroleum University, Daqing 163318, P. R. China
[2]China Petroleum Daqing Oilfield Limited Company, Daqing 163000, P. R. China

***Corresponding Author:**
He Wei
Email: 1511031999@qq.com

Abstract: The unconventional tight reservoir has experienced multiple geological processes, the types of reservoir are varied, the shape and size are different, the distribution is discrete, and the lithology is complex, resulting that the conventional modeling can't effectively solve the problem of the unconventional tight reservoir. Taking the characteristics of different scale pore, complex nature/ artificial fracture network in unconventional tight reservoir into consideration, this paper proposes a method that taking the characterization of micro-pore texture of unconventional tight sandstone and the techniques for identification and description of natural/ artificial fractures as basis, and contains the modeling of different scale pore and complex nature/ artificial fracture network. This method is mainly divided into 4 aspects, firstly, based on mercury injection data, the pore type reservoir is divided into 4 stages, and stochastic simulating the matrix reservoir distribution model controlled by sedimentary model; secondly, taking seismic data as basis, combined with advanced techniques such as ant-body, deterministic simulating the large scale natural discrete fractures networks controlled by human computer interaction; thirdly, according to the medium-small scale fractures by logging data and micro scale fractures by casting lamella data, calculating the fracture intensity curve, simulating the medium-small and micro scale discrete fracture networks by stochastic algorithm; finally, based on micro seismic data, simulating the different scale artificial fractures by combining the stochastic and deterministic algorithm. This paper take the upper sweet-point of development pilot area in Changji oilfield which is in Lucaogou Formation of Junggar Basin of Xinjiang as example, establishing the model of tight reservoir by the method above, highlight the characteristics of tight reservoir, providing the static model of multi-medium reservoir with high precision to numerical simulation.
Keywords: Tight reservoir; Different scale and multiple medium; The modeling of natural fractures; The modeling of artificial fractures; Junggar Basin; Lucaogou Formation.

INTRODUCTION

The unconventional tight reservoir has experienced multiple geological processes, the types of reservoir are varied, the shape and size are different, the distribution is discrete, and the lithology is complex, resulting that the conventional modeling can't effectively solve the problem of the unconventional tight reservoir, and there is no any mature modeling method and technique for tight reservoir [1, 2].

MODELING IDEAS

This paper proposes a modeling method that contains different scale pore and complex nature/artificial fracture network, and it mainly divided into the following 3 steps to complete. Firstly, making reservoir classification, considering that the unconventional tight reservoir contains fine fractions silty sandstone, carbonate and a variety of excessive lithology, this paper decided to divide the tight reservoir into two types, such as pore-type and fractured type. For the pore-type reservoir, based on the position and shape of the conventional mercury injection curve, also and the size of the pore, porosity and permeability, percolation mechanism and so on, divide it into four types; for the fractured type, divide the nature fracture into large scale, small and medium scale, micro scale and then combined with artificial fractures, a total of four types of fractures. Secondly, under the premise of the isochronous framework, following the principle of sedimentary facies control, combined with appropriate modeling algorithm, respectively, to complete the modeling of pore-type reservoir, its porosity and permeability and so on; in the meantime, according to the seismic data or the fracture development density, the discrete fracture network with different scales is obtained by using the combination of the deterministic and stochastic [3, 4]. Lastly, calculating the fracture seepage parameters, the multiple sets of discrete fracture model and the matrix model are used as the initial model of the numerical simulation of the dual medium reservoir.

APPLICATION EXAMPLES

The types of lithology in study area mainly are fine grained silty sandstone and thin layer carbonate, and the excessive lithology is well developed. Therefore, the complex tight reservoir with the coexistence of pore type and fractured type is formed. Pore type reservoirs are mainly primary intergranular dissolution pores, dissolution of intergranular pore, intergranular dissolved pores, intragranular dissolved pore, moldic pore, shrinkage pore, intergranular micropores, dissolved pores in cemen and microporous matrix; fractured reservoir is mainly dissolution fractures, pressure solution fracture, tectonic fracture, filled fracture, the interstratal fracture, contracted fracture. In addition, there are a large number of artificial fractures, affected by fracturing development mode. According to the core data, the average porosity is 9.17%, the average permeability is 0.15×10-3μm^2, a good normal distribution. More than 80% of the measured porosity of the sample is less than 10%, and more than 70% of the sample measured permeability is less than 0.1×10-3 μm^2. Therefore, its porosity and permeability is very low, the type of reservoir is tight, has poor physical properties and strong heterogeneity.

Pore type compact reservoir modeling

Based on conventional mercury injection data, combined with the core and casting lamella, mainly considering the the position and shape of the conventional mercury injection curve, also and the size of the pore, porosity and permeability, percolation mechanism and so on, making the conclusion of division (Tab.1), the reservoir is divided into four types.

Table 1: The standard of reservoir classification

Type	Effective Porosity (%)	Permeability $\times10^{-3}(\mu m^2)$	Maximum hole radius (μm)	The average capillary radius (μm)	Median pressure (MPa)	Displacement pressure (MPa)	Means	Coefficient of variation	Sample number
I	>16 /13.68	>1 /5.346	>2 /8.475	>0.5 /1.636	<8 /6.23	<0.35 /0.203	<12 /11.04	>0.2 /0.24	8
I I	12～16 /12.21	0.2～1 /0.835	0.5～2 /1.013	0.15～0.5 /0.269	8～15 /10.488	0.35～1 /0.807	12～13 /12.34	0.13～0.2 /0.15	13
I I I	7～12 /10.45	0.02～0.2 /0.046	0.1～0.5 /0.268	0.03～0.15 /0.073	15～30 /19.742	1～6 /3.512	13～14 /13.38	0.1～0.13 /0.109	15
IV	<7 /5.99	<0.02 /0.014	<0.1 /0.081	<0.03 /0.023	>30 /61.155	>6 /9.75	>14 /14.58	<0.1 /0.98	16

Based on the division of reservoir, under the premise of the isochronous framework, following the principle of sedimentary facies control, combined with appropriate modeling algorithm, respectively, to complete the modeling of pore-type reservoir, its porosity and permeability and so on; in the meantime, according to the seismic data or the fracture development density, the discrete fracture network with different scales is obtained by using the combination of the deterministic and stochastic (Fig.1). Moreover, using the reservoir distribution model as a constraint, taking the results of the logging as hard data, seismic data as soft data of porosity model, porosity model as soft data of permeability model and permeability model as soft data of oil saturation, analyzing of variation, we stochastic simulate the attribute model of pore type matrix [5, 6].

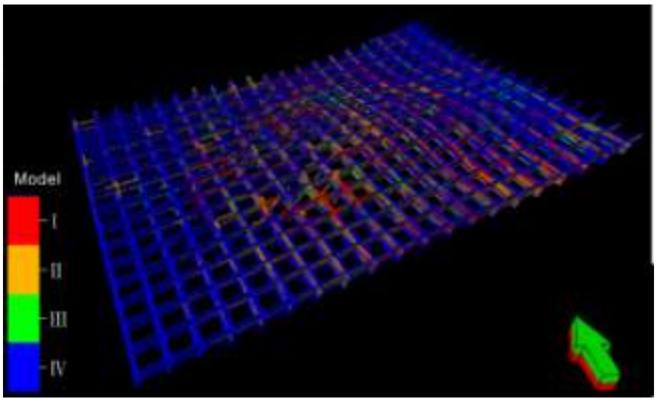

Fig-1: The distribution of pore type tight reservoir

Fig-2: The large scale discrete fracture networks

Analyzing the model of pore type matrix, the distribution of different types of reservoir exists obvious difference; its porosity and permeability are also different. The I type, its physical property is relatively good, the average porosity is 13.68%, the average permeability is 5.346×10-3μm2; The II type, its physical property is moderate preference, the average porosity is 12.21%, the average permeability is 0.835×10-3μm2; The III type, its physical property is moderate bias, the average porosity is 10.45%, the average permeability is 0.046×10-3μm2; The IV type, its physical property is poor, the average porosity is 5.99%, the average permeability is 0.014×10-3μm2.

The large scale discrete fracture networks

Starting from the aspect of seismic attribute, the depth domain seismic data body was carried on the processing of the technology such as the denoising, the construction smooth, and the edge enhancement and so on. Therefore, the properties of ants under different parameters were extracted, optimizing each of the ant body, under the guidance of the development mode of fracture in the target area, human-computer interaction to pick up the effective large scale fractures, we deterministic simulate the large scale discrete fracture networks(Fig.2). From the model, the study area mainly develops the NS and NNE trending fractures with large scale and high angle. The angle of NS trending fracture is 70°~90°, about 300 fractures; and the angle of NNE trending fracture is 60°~85°, about 60 fractures.

The small and medium scale discrete fracture networks

Based on the FMI imaging logging data, distinguishing the small and medium scale fractures, counting the characteristic parameters of the fracture, the fracture density curve is used as the hard data, the ant body as constraint, building the model of fracture growth density. Moreover, according to the fracture group, the small and medium scale discrete fracture networks are modeled (Fig.3). From the model, the study area mainly develop the NS trending small and medium scale fractures, with large quantity and high angle in which the high conductivity fracture own about 89% and high resistance fracture own about 11%. The accumulation zone is in the central and eastern regions of the study area, the angle range is between 20° and 90° mainly are 61°. Small and medium scale fractures are consistent with large scale cracks in trend, and more accompanied by large scale fractures near, it shows that large scale fracture have obvious control effect on small and medium scale fractures.

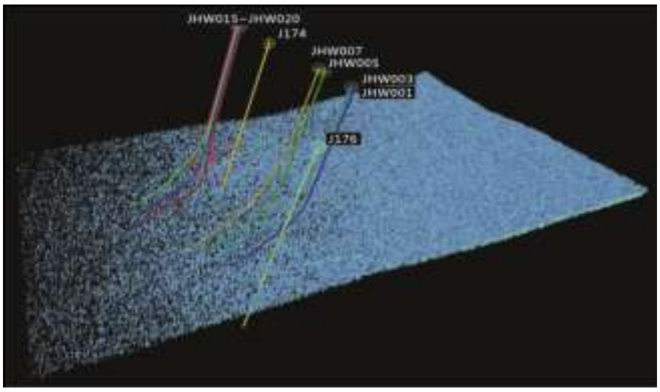

Fig-3: The medium and small scale discrete fracture networks

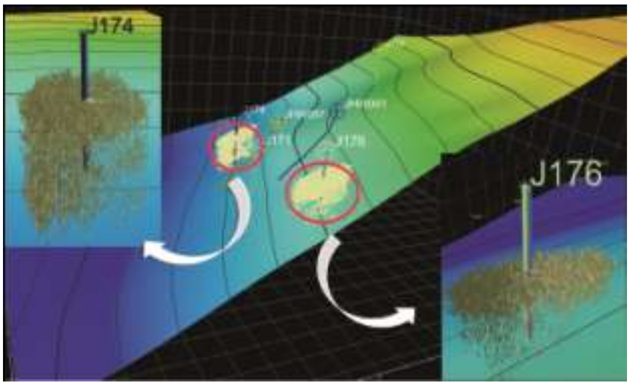

Fig-4: The micro scale discrete fracture networks

The micro scale discrete fracture networks

Based on casting lamella, combined with the understanding of the fractures, the data of fracture density, width, length and type is counted. Therefore, building the development pattern of single well micro fracture, calculating the fracture density curve and the model of micro fracture density, width, and length was established, under the control of the sedimentary. Moreover, using the stochastic method combined with a priori geological knowledge, the micro scale discrete fracture networks were established. This paper, using the stochastic method, established the micro scale DFN model that the J174, J176 well as the center, the predict radius of single well are 300 meters (Fig.4). Analyzing the model, near the J174 well, there exists about 25601 micro fractures, mainly concentrated in the upper, the lower part is relatively small; near the J176 well, there exists about 19973 micro fractures, mainly concentrated in the upper, the lower part is relatively small. The scale of each fracture is very small, less cross cutting, toward the NNE-SSW direction with high angle, the angle range is 30°~90°, mainly are 64.41°.

The artificial discrete fracture networks

On the one hand, the comprehensive application of each well micro seismic interpretation results, containing the fracture orientation, length, and the degree of support parameters, we use the Fraca Flow software to simulate the artificial discrete fracture networks of each well by the stochastic mothed. On the other hand, using the analytic equivalent simulation method of Fraca Flow, combined with the distribution of the natural fracture, human computer interaction optimizing the micro seismic event point, we established the optimal micro seismic volume model. And then, we stochastic simulate the micro scale discrete fracture networks on the constraint of the strength of fractures in volume. Analyzing the model, on the effect of the regional crustal stress, the artificial fracture is mostly perpendicular to the direction of the horizontal well trajectory, and nearly parallel to the maximum horizontal principal stress direction, it in agreement with the actual formation process of artificial fracturing (Fig.5).

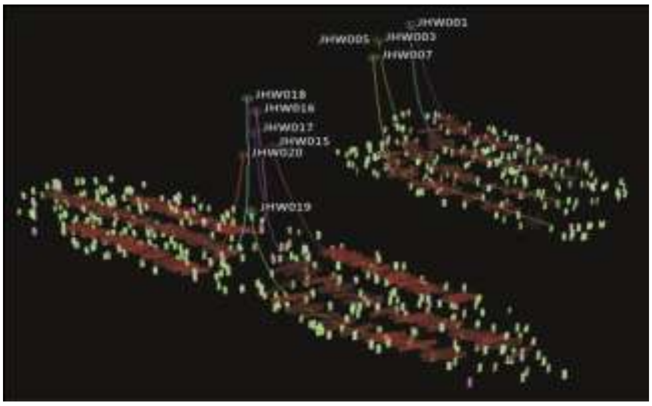

Fig-5: The multiple scale artificial discrete fracture networks

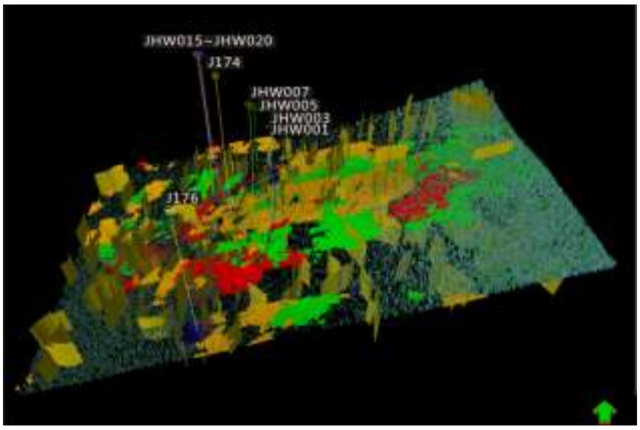

Fig-6: The matrix reservoir and fracture in the same grid system

Fusion model of different scales and multi-medium reservoirs

In order to provide the multi-medium static model to numerical simulation, in this paper, the different scale matrix model, natural/ artificial fracture model were upscaling according to different method. Moreover, sticking to the principle of dominant permeability, the optimal attribute values are given for each grid and a dual medium reservoir model with different scales and different scales of natural/ artificial fractures is obtained (Fig.6).

CONCLUSIONS

（1）Taking the upper sweet-point of development pilot area in Changji oilfield which is in Lucaogou Formation of Junggar Basin of Xinjiang as example, this paper propose a method that taking the characterization of micro-pore texture of unconventional tight sandstone and the techniques for identification and description of natural/ artificial fractures as basis, and contains the modeling of different scale pore and complex nature/ artificial fracture network.

（2）For the pore type reservoir, this paper propose a method that based on conventional mercury injection data, under the premise of the isochronous framework, following the principle of sedimentary facies control, the model of pore type reservoir was completed.

（3）For the fracture type reservoir, this paper propose a method that taking seismic data as basis to simulate the large scale fracture model, taking logging data as basis to simulate the small and medium scale fracture model, taking casting lamella data as basis to simulate the micro scale fracture model and taking micro seismic data as basis to simulate the artificial fracture model.

REFERENCES

1. Hou, J. G., Ma, X. Q., Liu, Y. M., & Zhao, B. (2012). Modelling of Carbonate Fracture-Vuggy Reservoir: A Case Study of Ordovician Reservoir of 4th Block in Tahe Oilfield. *Earth Science Frontiers*, *19*(2), 59-66.
2. Xiangyang, H., Xiangchun, Y., & Jiagen, H. (2014). Modeling method of carbonate fractured-cavity reservoirs using multiscale karst facies-controlling. *Acta Petrolei Sinica, 32*(2), 340-346.
3. Xiaoling, L., & Zhaojie, G. (2013). Fractured reservoir modeling method based on discrete fracture network model. *Acta Scientiarum Naturalium Universitatis Pekinensis, 49*(6), 964-972.
4. Xili, D., Jiahong, L., & Li, L. (2015). Advances in the study of fractured reservoir characterization and modeling. *Geological Journal of China Universities, 21*(2), 306-319.
5. Jinkai, W., Jinliang, Z., & Jun, X. (2014). Fracture identification and prediction model of ultra-low permeability reservoir in Haituozi oilfield, Southern of Songliao Basin. *Periodical of Ocean University of China, 44*(6), 081-084.
6. Chengmei, W., Zhineng, G., & Fuping, T. (2014). Early exploitation characteristics of Lucaogou tight oil of Permian in Jimusaer Sag, Junggar Basin. *Xin Jiang petroleum geology*, *35*(5), 570-573.