

A Quantitative Method for Evaluating the Oil and Gas Charging Capacity from Source Rock to Heterogeneous Reservoir

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Objective

The oil and gas charging capacity from source rock to heterogeneous reservoir is controlled by many geological factors (Jiang Youlu et al., 2017) and it is difficult to be quantitatively evaluated, limiting workers to understand the hydrocarbon charging process and favorable exploration direction. This work aims to determine the evaluation standard of geological factors that affecting the oil and gas charging capacity, and establish the quantitative equation for evaluating the oil and gas charging capacity.

Methods

In order to achieve the quantitative evaluation of oil and gas charging capacity from source rock to reservoir, we firstly analyzed the development of every geological factor and its effect on oil and gas charging capacity to form quantitative evaluation standard for every geological factor. Then according to the different influences among all geological factors on the oil and gas charging capacity, the quantitative evaluation equation was established.

Results

(a) Geological factors and their evaluation standard

The oil and gas charging capacity from source rock to heterogeneous reservoir is closely relate to source rock, reservoir and their contact relationship (Jiang Youlu et al., 2015). Based on the analyses of every geological factor development and its effect on the oil and gas charging capacity, every geological factor was graded into several parts which were assigned with different values to form a evaluation standard (Appendix 1). In which, the bigger of the value, the more favorable for the oil and gas charging.

(b) Quantitative equation for evaluating oil and gas charging capacity

Based on the different influences of all geological factors on the oil and gas charging capacity, the different weight values were assigned as follows: 0.1 for the hydrocarbon generation intensity, 0.25 for the source-reservoir contact relationship, 0.15 for the reservoir porosity, 0.4 for the reservoir permeability and 0.1 for the reservoir thickness. Then combing the quantitative evaluation standard of geological factors, the following equation (1) was established to quantitatively calculate the oil and gas charging capacity.

$$S = 0.1 \times HGD + 0.25 \times SR + 0.15 \times \frac{\Sigma(H_{\phi} \times W_{\phi})}{H_r} + 0.4 \times \frac{\Sigma(H_k \times W_k)}{H_r} + 0.1 \times W_H \quad (1)$$

In the above formulae, S is the oil and gas charging capacity index, and the greater S value indicates a stronger oil and gas charging capacity. HGD is the assigned value for hydrocarbon generation intensity. SR is the assigned value for the contact type between source rock and reservoir. H_{ϕ} is the thickness of the reservoir with certain porosity. W_{ϕ} is the assigned value for certain reservoir porosity.

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H_k is the thickness of reservoir with certain permeability. W_k is the assigned value for certain reservoir permeability. H_r is the total thickness of the reservoir. W_H is the assigned value for the thickness of the reservoir.

(c) Application of the above method

Taking the Jingxi area in the Ordos Basin as an example, the natural gas charging capacity indexes from the Carboniferous-Permian source rock to the Ordovician reservoir of 62 wells were calculated and compared with the actual gas productions. The results show that the natural gas charging capacity indexes have a significant positive correlation with the daily gas productions among the different gas-producing blocks (Fig. 1), reflecting that the oil and gas charging scale is related with its charging capacity and Blocks Su203 and Su217 belong to the most favorable exploration areas.

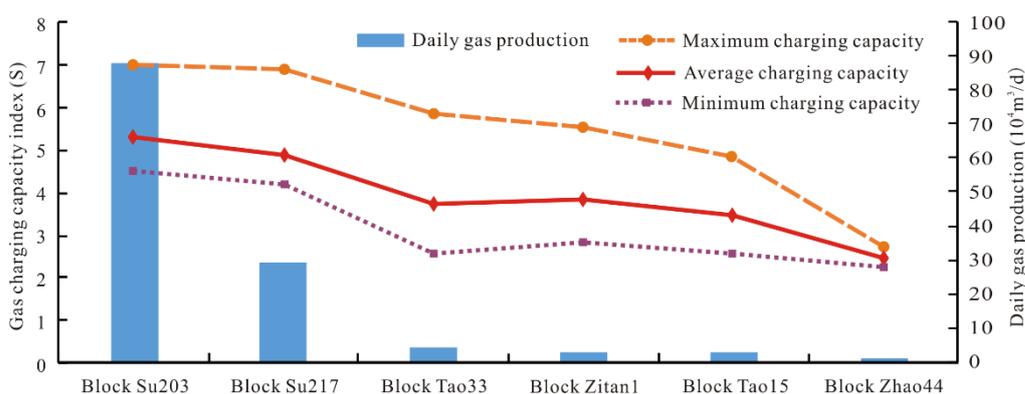


Fig. 1. Comparison between the gas charging capacity and daily gas production of the Ordovician reservoir in different blocks of the Jingxi area, Ordos Basin.

Conclusions

Based on the hydrocarbon generation intensity, the source rock-reservoir contact relationship, reservoir porosity, permeability and thickness, the quantitative evaluation standard of main geological factors and the quantitative equation of the oil and gas charging capacity were established. The method has been well used in the Jingxi area of the Ordos Basin, which helped explain the oil and gas enrichment difference in space, and predict favorable exploration areas.

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Appendix

Appendix 1 Quantitative evaluation standard of geological factors that affect oil and gas charging

Geological factor	Development	Assigned value	Development	Assigned value	Development	Assigned value	Development	Assigned value
Hydrocarbon generation intensity ($\times 10^3 \text{m}^3/\text{km}^2$)	≥ 22	8	18–22	5	12–18	4	< 12	2
Contact type between source rock and reservoir	Source rock-reservoir	8	Source rock with sand interlayer-reservoir	5	Source rock-sandstone-reservoir	2	/	/
Reservoir porosity(%)	≥ 6	10	4–6	6	2–4	4	≤ 2	2
Reservoir permeability (mD)	≥ 1	10	0.1–1	7	0.05–0.1	5	≤ 0.05	2
Reservoir thickness (m)	≥ 7	7	4–7	5	1–4	3	≤ 1	2