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Evaluation Standard and Methods of Source Rocks of Tight Oil in the Northern Songliao Basin

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The study of tight oil is one of the key research areas of the Daqing Oilfield in recent two years, and its proportion is growing in the incremental reserves and production. In 2014, the tight oil reserves accounted for 65.5% in the incremental oil reserves of middle-shallow layers in the north of the Songliao Basin, thus the study of tight oil has received more and more attention and becomes one of the most prominent researches in the field of petroleum geology. It is imperative to develop an evaluation standard of tight oil hydrocarbon source rock and it is fundamental for tight oil resource potential assessment, hydrocarbon accumulation mechanism and favourable exploration area prediction. It is also a great significance for the principle of sustainable development and oil reserve increment.

In the 1960s, the old generation of geologists proposed "source control theory", which means that oil and gas were generated from hydrocarbon source rock and then accumulated near source kitchens, i.e. source kitchens control the distribution of oil and gas fields. The tight oil research and source rock evaluation is more closely related and there are two points related to source rocks in the four factors affecting the formation of tight oil and gas. The first is a large area with high quality source rocks, and the second is the close contact between source rocks and reservoirs with short-range migration and accumulation. Therefore we must define high quality source rocks before making evaluation standards for tight oil source rocks. Due to the strong heterogeneity of hydrocarbon source rocks, the hydrocarbon potential of source rocks with different organic content is different. A research of many sampling wells with low maturity in middle-shallow layers in the Songliao Basin show that there is a good correlation between organic content and hydrogen index. With the increase of TOC (total organic content), and corresponding hydrogen index increases. However, when TOC>2%, the hydrogen index levels off at a certain range, e.g. 650-800 mg/g C, and the corresponding stable carbon isotopes of kerogen are relatively lighter, suggesting that hydrocarbon source rocks with TOC > 2% have similar nature. The conclusion was corroborated by microscopic analysis, which shows that source rocks with TOC > 2% in the middle-shallow layers of the Songliao Basin contain mainly alginite, indicating that source rocks with TOC > 2% in middle-shallow layers of the Songliao Basin is of high quality. The organic matter of high quality source rock is mainly laminar algae with less species and diversity, and they are dinoflagellate, yellow-green algae (botryococcus in general) and green algae (psiloschizosporisparvus in general) in the order of decreasing abundance. The hydrocarbon generation kinetic analysis shows that hydrocarbon is generated in a narrow maturity range with late expulsion (at about *R*o=0.75 %), in accordance with global typical lacustrine source rocks. Therefore, we use TOC > 2%, HI_0 (original hydrogen index) of 650-800 mg/gC as evaluation standards to define class I source rock of tight oil in the middle-shallow lithologic reservoirs of the Songliao Basin. Besides abundant organic matter, enough thermal stress is also needed to let the high quality source rocks release its hydrocarbon potential. According to the analysis of large measured data from wells with different maturity, we found that for source rock samples with TOC > 2%, when *R*o reaches 1.3%, the HI could decrease to about 100 mg/g C and the expulsion efficiency could reach 85%. In the study of high-pressure autoclave hydropyrolysis experiment, the result from high quality source rock samples with TOC > 2% is in accordance with the conclusion from measured data. Pepper et al. (1995) show that when the HI of source rock is between 700-800 mg/g C, the expulsion efficiency is between 65-85%, which is consistent with the above conclusions. Because of the density of generated oil at higher maturity is relatively low, the GOR is relatively high and the fluidity is relatively good. Currently, the tight oil we have found in the north of

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the Songliao Basin is mainly in the range of *R*o more than 1%, so that we define TOC > 2%, Ro of 1.0%-1.3% and expulsion efficiency of 70%~85% as the standard for class I source rock of tight oil. The standard of class III source rock of tight oil mainly refers to low organic content with marginal maturity and low expulsion efficiency. The standard of class II is between class I and class III (Table 1).

Table 1 The evaluation standard of source rocks of tight oil in Northern Songliao Basin

Evaluation Parameters	Classification		
	I	II	III
TOC %	> 2	1-2	0.5-1
HI_0 mg/g C	650-800	300-650	200-300
Expulsion Efficiency %	70-85	10-70	< 10
*R*o%	1.0-1.3	0.8 -1.0	0.75-0.8

Although the distribution and thickness of high quality source rocks also control the distribution of tight oil, however, in the middle-shallow lithologic reservoirs of the Songliao Basin, where high quality source rocks are widespread, especially in the K_2qn^1 member, they cannot be the key parameters.

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