WANG Wenguang, LU Shuangfang, WANG Min, ZHENG Min, HUANG Aihua, WANG Zhiwei and JI Tianliang, 2015. Evaluation of Hydrocarbon Yield of Organic Matters with Hydrocarbon Generation Kinetics Method： An Example from the K_1*qn* Formation of the Songliao Basin. *Acta Geologica Sinica* (English Edition), 89(supp.): 453-456.

Evaluation of Hydrocarbon Yield of Organic Matters with Hydrocarbon Generation Kinetics Method : An Example from the K_1*qn* Formation of the Songliao Basin

WANG Wenguang[1, 2], LU Shuangfang[2*], WANG Min[2*], ZHENG Min[3], HUANG Aihua[1], WANG Zhiwei[2] and JI Tianliang[2]

1 Northeast Petroleum University, Daqing City, Heilongjiang 163318
2 China University of Petroleum (East China), Qingdao, Shandong 266580
3 Research Institute of Petroleum Exploration & Development, PetroChina, Beijing 100083

1 Introduction

Hydrocarbon yield from organic matters is the one of the key parameter of petroleum resource assessment. Previous methods of hydrocarbon yield from organic matters included thermal simulation experiment method, element conservation method and hydrocarbon generation kinetics method (Liu et al, 2006; Tang et al, 2013). Among them are the following, thermal simulation experiment method is divided into open system experiment apparatuses (autoclave apparatuses, gold - tube pyrolysis apparatuses, MSSV apparatuses), closed system experiment apparatuses (Rock - Eval apparatuses and TG - MS apparatuses) and semi - open system experiment apparatuses (thermal simulation apparatuses of generation and expulsion hydrocarbon of direct pressure type, self - purging system apparatuses and compaction system experiment apparatuses), this method is based on the temperature - time complementary principle. Through the simulation of the generation hydrocarbon process of organic matters, we obtain the hydrocarbon yield from organic matters under the experimental conditions, the advantages of this method is simple, the disadvantage is that the hydrocarbon yield evaluated by the different thermal simulation apparatuses, the different experiment method and the different experiment condition (add water, no water, pressure, no pressure) are different, and it is difficult to determine which kind of experiment methods to measure the hydrocarbon yield more accurate. Element conservation method is based on element conservation theories, an alternate method is introduced, which can establish the hydrocarbon yield from organic matters according to a thorough H/C atomic ratio changes (Zhang, 2007), this method is easier compared with the thermal simulation experiment method; But elements (C, H , O) determination is constrained by the rock samples and the funding, which can not meet the accuracy and the comprehensiveness. Hydrocarbon generation kinetics method, based on the thermal simulation experiment data from organic matters and crude oil, used the calibration model of hydrocarbon generation kinetics parameter, obtained the kinetic parameters of different kerogen types, combined with the burial history in the study area for dynamic geological extrapolation, implemented the purpose that the hydrocarbon yield under the experimental conditions was in consistency with the hydrocarbon yield under the geological conditions, which got in line with the geological understanding of the hydrocarbon yield. This paper has built the hydrocarbon yield evaluation method and the chart from organic matters that was constrained by the thermal simulation experimental data, the kinetics dynamics theory, and the actual geological target data (the burial history, the thermal history, hydrocarbon generation threshold depth), implemented the purpose that the hydrocarbon yield from organic matters was in agreement with the hydrocarbon threshold depth and the degree of thermal evolution of organic matters, and had a solid theoretical foundation and strong applicability.

2 Evaluation of Hydrocarbon Yield of the K_1qn Formation

2.1 Quality of source rock of the K_1qn Formation

* Corresponding author. E-mail: 846043531@qq.com and quickking@163.com

Organic matters is the material basis of the generation of oil and gas. The quality of source rocks mainly depends on the organic matter abundance, the organic matter type and the organic matter maturity. Source rocks of the K_1qn Formation belong to the typical lacustrine source rocks in the Songliao Basin Northern, which is the source rock with good quality.

It can be seen from the Table 1 (Huo, 2012), the average TOC of the K_1qn^1 Formation was 2.84%, chloroform bitumen "A" was 0.421%, the hydrocarbon potential was 16.37 mg/g, the above parameters showed a large lacustrine basin sedimentary characteristics of high-quality hydrocarbon source rocks; the average TOC of the K_1qn^{2+3} Formation was 1.11%, chloroform bitumen "A" was 0.148%, the hydrocarbon potential was 6.05 mg/g.

Organic matter type of source rock of the K_1qn^1 Formation were mainly the type I and the type II_1 that were given priority to the oil, which indicated that organic matter mainly came from the deep lake that was rich in fat and lipids in the body of aquatic organisms, plankton, microbes, and terrigenous spores and pollen mixed organic matter; Organic matter type of source rock of the K_1qn^1 Formation were mainly the type I and the type II_1, and existed a certain number of the type II_2 and the type III, which reflected that the source of organic matter was complicated.

The maturity Ro of source rock of the K_1qn^1 Formation distribute between 0.3% and 1.5%, locate at the immature stage and the mature stage; The maturity Ro of source rock of the K_1qn^{2+3} Formation distribute between 0.3% and 1.0%, locate at the immature stage and the low - mature stage;

Organic matter is the material basis of the generation of oil and gas. And the hydrocarbon yield is the key parameters of the hydrocarbon potential of the K_1qn Formation, which is crucial for hydrocarbon generation potential and residual hydrocarbon resource from the K_1qn Formation.

2.2 Evaluation of Hydrocarbon Yield

This paper took the evaluation of the hydrocarbon yield from the source rock of the K_1qn Formation of the Songliao Basin Northern as an example, the specific steps were as follows: ① We collected rock samples (Ro<0.5%, TOC>1.0%) of the K_1qn Formation of Sheng 1 well in the Songliao Basin Northern, obtained the Rock-eval, PYGC thermal simulation experiment data from organic matters and gold-tube thermal pyrolysis experiment data from crude oil; Meanwhile, we obtained the test data of rock pyrolysis analysis, the test data of total organic carbon analysis and the test data of chloroform bitumen "A" analysis; ② We collected the previous geochemical parameters of organic matters of the K_1qn Formation, and drilling strata data, the paleogeothermal gradient data, paleo land surface temperature data; ③ we used Rock-eval, PYGC thermal simulation experiment data from organic matters and gold-tube thermal pyrolysis experiment data from crude oil, adopted the calibration model of hydrocarbon generation kinetics parameter, calibrated gas from kerogen cracking parameter, oil from kerogen cracking parameter and gas from oil cracking parameter; ④ Based on the drilling strata data, paleogeothermal gradient data and paleo land surface temperature of the Songliao Basin Northern, we established the burial history of sources rock of the K_1qn Formation; ⑤ Based on the geochemistry data of sources rock of the K_1qn Formation, we determined the generation hydrocarbon threshold depth and the degree of thermal evolution of organic matters etc transform rate constraint conditions (Fig. 1a, Fig.1b, Fig.1c), the generation hydrocarbon threshold depth of the K_1qn Formation of the Songliao Basin Northern was 1550m, corresponding to the vitrinite reflectance Ro was 0.65%; the expulsion hydrocarbon threshold depth of the K_1qn Formation of the Songliao Basin Northern was 2000m, corresponding to the vitrinite reflectance Ro was 1.0%; the organic matter types of source rocks were mainly the type I and the type II_1; The hydrocarbon potential of source rock was 800 mg/g TOC; ⑥ We carried out the kinetics dynamic geological extrapolation with hydrocarbon generation kinetics method, established transform rates (oil from kerogen cracking, gas from kerogen cracking) of organic matters under the open system experimental conditions and transform rates (net oil and total gas) of organic matters under the closed system experimental conditions for source rock of the K_1qn Formation of the Songliao Basin Northern (Fig.1d and Fig.1e), adopted the hydrocarbon generation threshold depth of source rock of the K_1qn Formation and the degree of thermal evolution of organic matters to constrain the result of the kinetics dynamic geological extrapolation, implemented the purpose that the result of the dynamic geological extrapolation was in agreement with the current geological understanding. ⑦ We introduced the adjustment coefficient of this concept. The adjustment coefficient [0, X, 1] was given according to the oil field exploration and practice, represented the primary migration situation for oil from kerogen cracking; We determined the adjustment coefficient of the gas from residual oil cracking under semi - open system experimental conditions according to the oil field exploration and practice, and evaluated the transform rates of organic matters under semi - open system experimental conditions (Fig. 1f and Fig. 1g); ⑧ Based on the evaluation of the transform rates of organic matters,

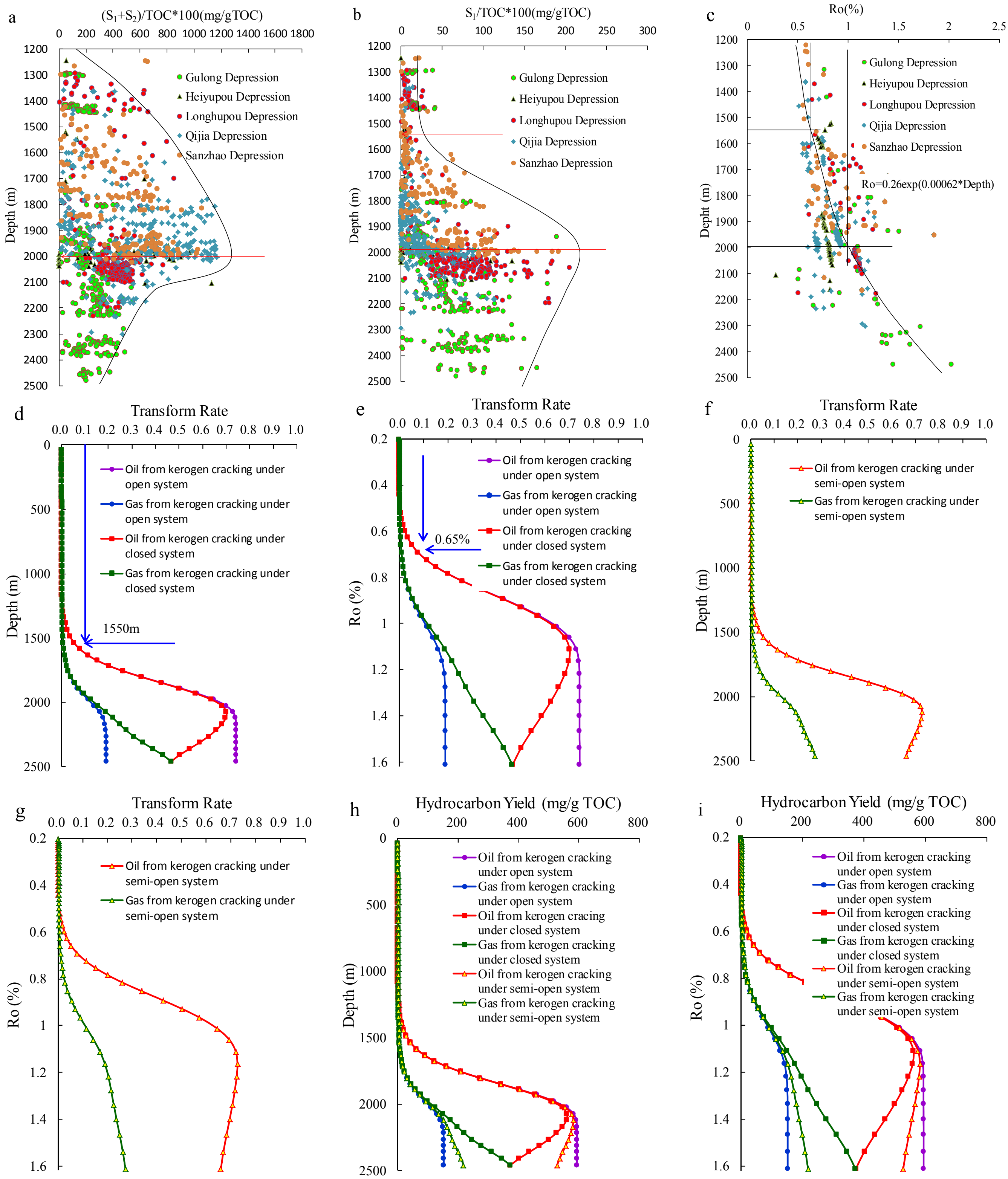

Fig.1 Hydrocarbon yield template and geochemical parameters profile from organic matters of the K_1qn Formation of the Songliao Basin Northern. a – the relation between (S_1+S_2)/TOC*100 (mg/g TOC) and depth (m). b – the relation between S_1/TOC*100 (mg/g TOC) and depth (m). c – the relation between depth (m) and Ro (%). d – the relation between depth (m) and hydrocarbon yield (mg/g TOC) under open system and closed system. e –the relation between Ro (%) and the hydrocarbon yield (mg/g TOC) under open system and closed system. f - the relation between depth (m) and the hydrocarbon yield (mg/g TOC) under semi-open system. g - the relation between Ro (%) and the hydrocarbon yield (mg/g TOC) under semi-open system. h – the relation between depth (m) and hydrocarbon yield (mg/g TOC) under open system, closed system and semi-open system. i – the relation between Ro(%) and hydrocarbon yield (mg/g TOC) under open system, closed system and semi-open system.

combined with the hydrocarbon potential of source rock, we built the hydrocarbon yield - Ro profile and the hydrocarbon yield - depth profile (Fig.1h and Fig. 1i) that contained the hydrocarbon yield under the open system experimental conditions, the closed system experimental conditions and the semi-open system experimental conditions; This paper solved the problem that the previous thermal simulation experiment data of the source rock was not in agreement with the evolution of the hydrocarbon source rock under the geological conditions, successfully evaluated the accurate and reasonable hydrocarbon yield from source rock of the target horizon.

Based on the hydrocarbon yield from organic matters of the K_1qn Formation under semi - open system experimental condition, combined with Ro contour of the K_1qn Formation, we got the contour of the oil yield, the gas yield and the hydrocarbon yield from organic matter of the K_1qn Formation, and provided the key parameters for the evaluation of hydrocarbon potential of organic matters of the K_1qn Formation.

3 Conclusion

This paper has built the hydrocarbon yield evaluation method and the chart from organic matters that is constrained by the thermal simulation experimental data, the kinetics dynamics theory and the actual geological target data (burial history, thermal history, hydrocarbon expulsion threshold depth), implemented the purpose that the hydrocarbon yield from organic matters were in agreement with the hydrocarbon threshold depth and the degree of thermal evolution of organic matters, and had a solid theoretical foundation and strong applicability.

Acknowlegements

This work was sponsored by the National Science Foundation of China (Grant No. 41302101, 41330313) and Oil and Gas Resources Assessment (Grant No. 2013E-0502).

Author Introduction

Wang Wenguang (1988-), Male, the Fujin City of Heilongjiang Province, Master Graduate Student, Mineral Resource Prospecting and Exploration, mainly Engaged in the Generation Hydrocarbon of Organic Matter, Conventional and Unconventional Oil and Gas Accumulation Mechanism Research, E-mail: wangwenguang.0@163.com.

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