

Research Advances

New Progress on Hydrocarbon-generation History of the Dongpu Depression in the Bohai Bay Basin based on Thermal History and Hydrocarbon Generation Kinetics



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Objective

Oil and gas exploration in the Dongpu Depression of the Bohai Bay Basin has penetrated deeply buried formations, which are generally at depths more than 3500 m, mainly the Shahejie 3 Formation. However, the hydrocarbon-generation potential, model and processes for different types of kerogen in this depression have been rarely documented. Aiming at this problem, this work conducted high-temperature and high-pressure pyrolysis experiments in a closed gold tube-autoclave system on different types of kerogen. Combined with the kinetic parameters and thermal history of the Dongpu Depression, this work restored the hydrocarbon generation histories of different types of kerogen and discussed the hydrocarbon generation potential for the main source rock in the sags by basin simulation technology. The results may provide important parameters for hydrocarbon generation characteristic determination and petroleum resource re-evaluation in the Dongpu Depression.

Methods

The hydrocarbon generation kinetics and hydrocarbon generation history are based on kerogen pyrolysis experiments conducted at the Guangzhou Institute of Geochemistry, Chinese Academy of Sciences. First, a closed gold tube-autoclave system was used to simulate the hydrocarbon generation of 8 kerogen samples to establish the hydrocarbon generation mode of different types of kerogen. Then, the software of Kinetics 2000 was used to calculate the pre-exponential factors (A) of different components and the activation energies (E) of the reactants to further establish the kinetic parameters of different types of kerogen in the Dongpu Depression. Based on the thermal history and geochemical parameters, the hydrocarbon generation histories of different source rocks in these sags were modeled using the software of BasinMod 1D.

Results

(1) Advantages of research methods for hydrocarbon generation history based on thermal history and hydrocarbon generation kinetics

The method of determining hydrocarbon generation history is based on the organic matter composition structure and chemical reaction kinetics, and there no empirical parameters are considered. Therefore, considering the kinetic pyrolysis experiments on certain source rocks in certain basins, the hydrocarbon generation kinetic parameters of a specific kerogen type are more consistent with the actual situation. This research established the hydrocarbon generation kinetic parameters of the different types of kerogen in the Dongpu Depression for the first time. Moreover, the temperature change rate of typical wells is reproduced on the basis of the thermal history. Thus, the simulation conditions are consistent with the actual geological conditions. In addition, the hydrocarbon generation history is simulated using basin simulation software of BasinMod 1D. Therefore, studying the hydrocarbon generation history constrained by the thermal history and hydrocarbon generation kinetics is more accurate for restoring the hydrocarbon generation process in a basin, thus resulting in a more realistic and more reliable simulated hydrocarbon generation history.

(2) Hydrocarbon generation histories

Based on the thermal history and the present geothermal fields, the hydrocarbon generation histories of the Shahejie 3 Formation were restored by basin simulation techniques, which combined the kinetic parameters of different kerogen types.

Take Well M11-7 as an example. The hydrocarbon generation processes of the oil and gas encountered by this well are similar. The hydrocarbon generation process at the bottom of the Shahejie 3 Formation can be divided into two stages: (1) from the middle period of the Shahejie 3 Formation deposition to the middle period of the Dongying Formation deposition, it is the main

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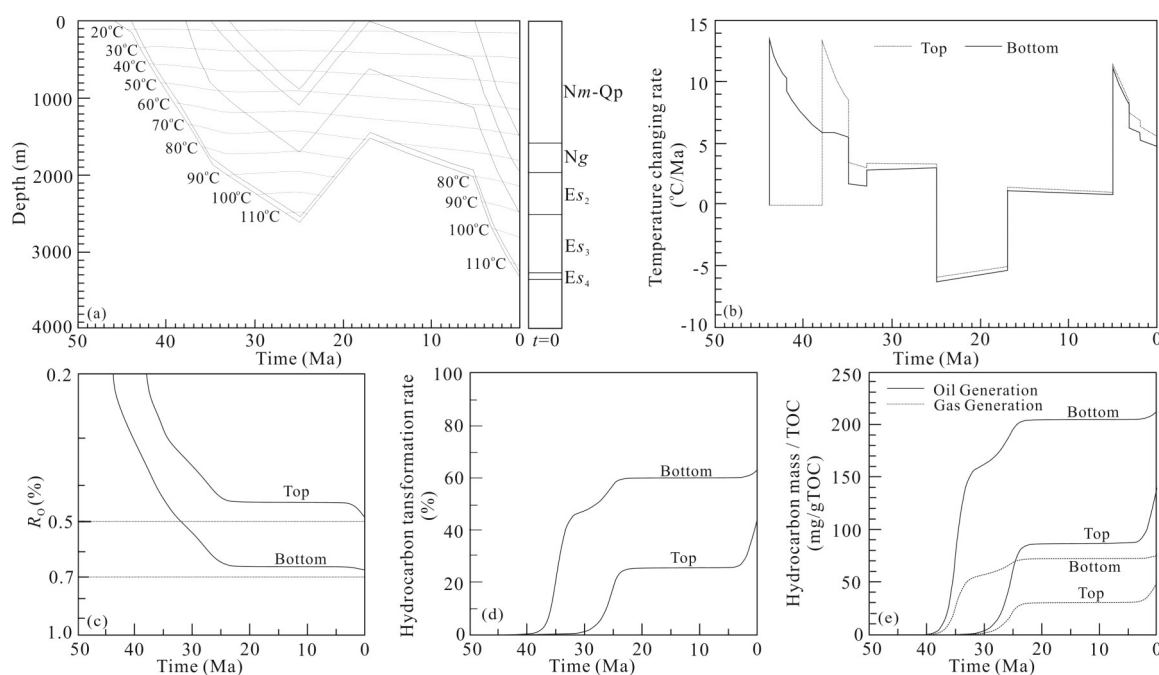


Fig. 1. Simulation results of the hydrocarbon generation history of the Shahejie 3 Formation at the Well M11-7.

(a) Burial and thermal histories; (b) Temperature changing ratio; (c) Maturity history; (d) Hydrocarbon transformation rate; (e) Hydrocarbon generation history.

hydrocarbon generation stage, and (2) from the end of the Minghuazhen Formation depositional period to the present day, which has a slow hydrocarbon generation and reaches the maximum oil and gas generation potentials, with maximum values of 213 and 75 mg/g TOC, respectively (Fig. 1). The other seven samples were also analyzed, and indicate that the source rocks of Well C9 (type II₁) and Well X8 (type III) have reached the maturity stage and have a higher transformation rate.

(3) Hydrocarbon generation potential evaluation in the main sags

Based on the previous hydrocarbon generation history, combined with the geochemical parameters and the thickness of source rocks, the hydrocarbon generation potential of the Haitongji - Liutun, Qianliyuan, Menggangji and Gegangji sags in the Dongpu Depression is evaluated. The results show that the Qianliyuan sag has the greatest hydrocarbon generation potentials with maximum oil and gas productions of 149 and 125 mg/g TOC, respectively; followed by the hydrocarbon generation potentials of the Haitongji-Liutun and Gegangji sags; the Menggangji sag has the lowest hydrocarbon generation potentials with maximum oil and gas productions of 61 and 51 mg/g TOC, respectively.

Conclusions

(1) This work established a method for determining

hydrocarbon generation history based on thermal history and hydrocarbon generation kinetics.

(2) Source rocks in the Dongpu Depression are mainly developed in the Qianliyuan and Haitongji-Liutun sags. They experienced the main hydrocarbon generation period from the middle period of the Shahejie 3 Formation deposition to the middle period of the Dongying Formation deposition, and then stopped generating hydrocarbon. Their maximum oil and gas generation potentials are 149 and 125 mg/g TOC in the Qianliyuan sag, and 121 and 69 mg/g TOC in the Haitongji-Liutun sag, respectively, while those in the Menggangji and Gegangji sags are undeveloped. There are two stages of hydrocarbon generation in the Menggangji and Gegangji sags: from the middle period of the Shahejie 3 Formation to the middle period of the Dongying Formation and from the Minghuazhen Formation to the present day.

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