A New Calculation Model of Hydrocarbon Generation, Expulsion, Retention and its Application based on geochemical data

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Introduction

The exploration potential of eight types of resources (i.e., shale oil and gas, coalbed methane and oil, tight oil and gas, conventional oil and gas) has drawn scholars' attention for a long time. A lot of researches, in relation to their genetic and accumulation mechanisms, have been conducted. However, the study of their genetic correlation, distribution characteristics, and evaluation of resource potential of conventional and unconventional hydrocarbon resources is rare. Based on previous research results, the hydrocarbon charging into high porosity and permeability reservoirs mainly results in conventional hydrocarbon resources. Conversely, the unconventional hydrocarbon resources will come into being when the hydrocarbon charge into low porosity and permeability reservoirs. Besides, the hydrocarbon generated from source rocks and retaining in them, featured by the "integration of reservoirs and source", mainly form the inter-source unconventional hydrocarbon resources, such as shale oil and gas. The decrease of (S_1+S_2)/TOC, which is the hydrocarbon generation potential, during source rock evolution indicates that the parts of hydrocarbon have been expelled from the source rocks.

Results

Based on the above principle, a new resource evaluation method can be proposed, the operational model is shown in figure1. Follow the steps below: (1) The hydrocarbon generation ratio is obtained by hydrocarbon potential restoration using (S_1+S_2)/TOC index (Pgr) , furthermore, the hydrocarbon expulsion ratio can be acquired by material balance theory. (2) Using S_1/TOC index and light hydrocarbon compensation correction, residual liquid hydrocarbon ratio is calculated. Additionally, the ratio of gas/liquid hydrocarbon (k) is obtained by experiments of hydrocarbon generation kinetics, therefore, residual gaseous hydrocarbon ratio (Pr_g) is got. (3) Based on the above ratios of hydrocarbon generation, expulsion , residual (liquid and gaseous), as well as the thickness, area, density and total organic carbon of source rocks, the quantity of hydrocarbon generation, expulsion, residual (liquid and gaseous) can be calculated respectively (formula 1 to 5). (4) Given the match relation between hydrocarbon expulsion history and reservoir compact history, we determined certain porosity (Φ = 12%) as upper limit of tight reservoir, conventional resources outside the source and tight unconventional hydrocarbon resources can be obtained respectively by variation characteristics of hydrocarbon expulsion.

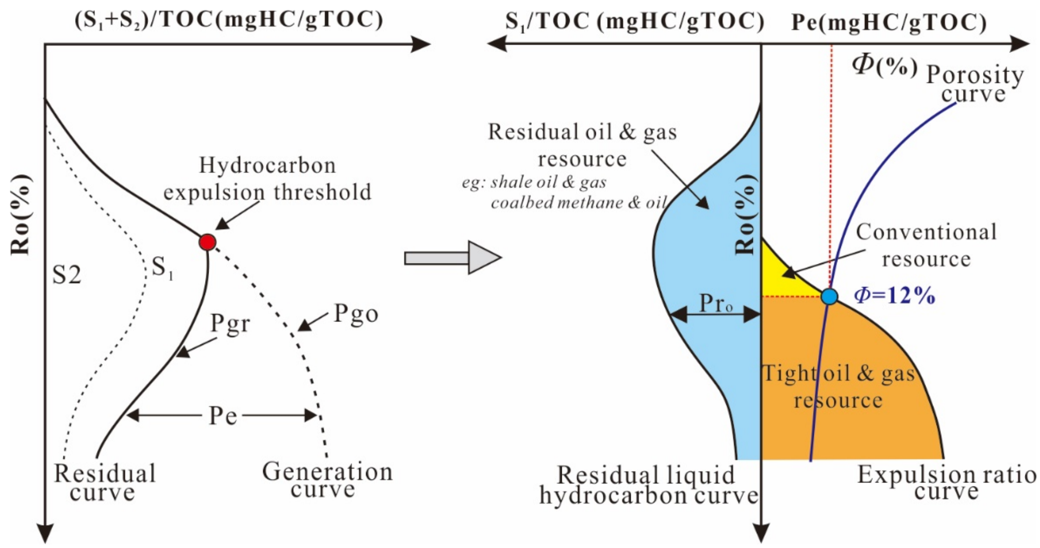

Figure1. *Operational model for the qualification of hydrocarbon generation, expulsion and retention*

$$Q_{pg} = \int_{R_{o1}}^{R_o'} 10^{-4} \times Pg_o \times h \times A \times \rho \times TOC \times dR_o \quad (1)$$

$$Q_{pe} = \int_{R_{o2}}^{R_o'} 10^{-4} \times Pe \times h \times A \times \rho \times TOC \times dR_o \quad (2)$$

$$Q_{ro} = \int_{R_{o1}}^{R_o'} 10^{-3} \times Pr_o \times h \times A \times \rho \times TOC \times dR_o \quad (3)$$

$$Q_{rg} = \int_{R_{o1}}^{R_o'} 10^{-4} \times Pr_g \times h \times A \times \rho \times TOC \times dR_o \quad (4)$$

$$Pr_g = Pr_o \times k \quad (5)$$

Here, Qpg, Qpe and Qrg are the amounts of hydrocarbon generated, expelled and residual gas, repectively, ×1012 m3; Qro is the amounts of residual oil, ×108 t; k is the residual gas/liquid ratio from hydrocarbon generation kinetics; Ro is the vitrinite reflectance, %; Ro1 and Ro2 are the hydrocarbon generation and expulsion thresholds, respectively, %; TOC is the total organic carbon content, %; h is the source- rock thickness, m; ρ is the source-rock density, g/cm3; and A is the source-rock area, m2.

Conclusions

This method is applied in Upper Paleozoic in Ordos Basin, China. A comparison with the Chanese third round oil and gas resources evaluation results suggests that the estimates using two different approaches are compatible.