Paper Number: 675

Unlocking Key Factors of Liquid-Rich-Shales: "Massive Resource Area" & "Sweet Area" Evaluation

Yang, Z., Zou, C.N., Hou, L.H., Tao, S.Z., Lin, S.H., Wu, S.T., Pan, S.Q.

Research Institute of Petroleum Exploration and Development, PetroChina
910 P.O., No. 20 Xueyuan Rd., Haidian District, Beijing, China, 100083; yangzhi2009@petrochina.com.cn

---

Liquid hydrocarbons in shale strata include two kinds of resources, i.e. tight oil and shale oil. Based on the exploration and research progress of liquid hydrocarbons in shale at home and abroad, their formation condition, accumulation mechanism, classification, and differences between lacustrine and marine shale system are examined, and "sweet area" are evaluated further. Analysis on the geological characteristics of the liquid hydrocarbons in the shale strata in North America and China shows the liquid hydrocarbons have two basic features: (1) large-scale continuous distribution, (2) no stable industrial production; in addition, the massive accumulation of the liquid hydrocarbons needs four fundamental formation conditions: stable tectonic background, widespread high quality source rocks, large-scale tight reservoirs with massive reservoir space, and co-existence of source and reservoir. The study reveals the formation mechanisms of the liquid hydrocarbons: source-reservoir coupling and porosity decrease during the diagenetic tightness; and identifies 24 kinds in 6 categories of the liquid hydrocarbons. It is concluded that the geological conditions of the lacustrine shales in China are characterized by lower thermal gradient and stronger heterogeneity than those of North America, so large scale "sweet area" have to be picked out to push up industrial production steadily. "Sweet area" evaluation should consider the three aspects of geology, engineering and economics comprehensively, and the maturity of source rocks is first and foremost factor controlling the "sweet spot" distribution. In China, prospective shale areas should meet the following conditions: the Ro between 0.8% and 1.3%, TOC higher than 2%, laminated shales or tight porous reservoirs, higher porosity (more than 8% for tight oil, and more than 3% for shale oil), higher content of brittle minerals (more than 70% for tight oil, and more than 40% for shale oil), oil saturation of more than 50%, lower crude oil viscosity or higher formation pressure, and rich natural fractures.

In the evaluation of "sweet areas" of liquid-rich hydrocarbons in lacustrine shale strata, the features of lacustrine shales, multiple tectonic evolution cycles, big lithofacies change, strong anisotropy and complex oil/water relationship etc should be kept in mind. Evaluation on fine-grained sediment mode and favorable sedimentary microfacies, multiscale characterization of reservoir beds, evaluation on effective reservoir space, occurrence mechanism of liquid-rich hydrocarbons, oil potential evaluation, petrophysical response mechanism and geophysical evaluation and prediction, modeling and evaluation of hydraulic fracture propagation in horizontal wells, integrated and quantitative "sweet areas" evaluation should be strengthened. Meanwhile, some techniques (such as in-situ upgrading/conversion and gas displacement, etc.) should be explored; new and suitable techniques should be researched and developed.

Liquid hydrocarbons in shale formations are huge in resource scale, so deepening the geological understanding on the formation and distribution of liquid hydrocarbons in marine and lacustrine shales constantly is of great significance for exploration and development of this important field.

References:

[1] Zou C, Yang Z, et al. (2012) Petroleum Exploration and Development 39(1): 15-32

[2] Zou C, Yang Z, et al. (2013) Petroleum Exploration and Development 40(1): 15-27
[3] Zou C, Yang Z, et al. (2013) Petroleum Exploration and Development 40(4): 413-428
[4] Zou C, Yang Z, et al. (2014) Petroleum Exploration and Development 41(1): 14-30
[5] Yang Z et al. (2015) Petroleum Exploration and Development 42(5): 609-620