Organic-rich shale porosity evolution from physical modelling

CUI JINGGANG[1*], GAO ZHIYONG[1], WU SONGTAO[1] AND SU LING[1]

[1]PetroChina Research Institute of Petroleum Exploration & Development (RIPED), No. 20 Xueyuan Rd., Beijing
*Correspondence: cuijingg@petrochina.com.cn

The study on porosity evolution of shales can help to improve the accuracy of reservoir evaluation and prediction, which is important to sweet-spotting. In this study, we use self-designed reservoir diagenetic modeling system to characterize shale porosity changes with increasing temperature (T) and pressure (P). Tmax=550°C and Pmax=275MPa. There are six sample reactors which can be set different T and P. We can add different fluids and collect the products during the experiment.The samples are modern lacustrine ooze obtained from Fuhai Lake of the Winter Palace in Beijing. TOC is 4.76 wt%. Six experiments have been conducted, and three experiments are at the same T&P to test system stabality. The heating rate is 10°C per hours and the pressure rise step is 10MPa per time. In this study, constant pressure (40MPa) is used. Total experiment time is 7 days. Typical diagenetic indicators, i.e., Ro, Tmax, Illite/smectite ratio are analyzed. SEM is used to obtain high resolution micro-structure images. Our prelimanary results include the following aspects:

(1) Three comparasive groups with 18 samples shows that the difference of Ro is less than 0.2%, indicating good stability of the system.

(2) Relationship between experiment T and maturity is established. 250°C correspond to immature stage when Ro = 0.5%. 250~370°C correspond to oil window when Ro = 0.5%~1.2%. 370 °C corresponds to gas window when Ro = 1.3%. 550°C corresponds to late gas window when Ro=2.5%.

(3) At early stage (Ro=0.5%), primary intergranule micro-pores dominate storage space. As T&P increase, the shale enter oil window (Ro=0.7%~1.2%) and the pore space is dominated by nano-scaled pores, usually accompanied with micro-fractures, which could form favorable nano-porosity system with better connectivity. During the gas window stage (Ro>1.3%), the adsorption of nano-scaled grains is great, which accelerate the process of OM pyrolysis. OM coagulation is observed around nano-scaled grains in mudstone/shale.

Although there are lots of differences between physical modelling and actural geological evolution, multi-parameter diagenesis modeling could help to understand the whole porosity and mineral evolution process in shale, which can provide reference for favorable reservoirs evaluation and prediction.