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Porosity Evolution of Lacustrine Organic-matter-rich Shales in China

ZHAI, X.F. and WU, S.T.

Research Institute of Petroleum Exploration and Development, PetroChina, No. 20 Xueyuan Rd., Beijing, zhaixiufen@petrochina.com.cn

The porosity evolution in shales is more complex than that in sandstones, due to special hydrocarbon (HC) generation in shales. Lots of scientists are trying to interpret this process via SEM observation on geological samples with different maturities, which is view-based and can provide useful information. However, it is too difficult to find the same organic-matter (OM) from different samples. Artificial-maturation is a good way to get relatively homogeneous samples, and can provide useful in-situ information to understand changes at different maturity. However, the current studies only use gas adsorption to provide quantitative analysis on whole pore system. Moreover, they can't separate OM pores from in-organic pores. Therefore, a new method that can provide information of different pores is urgently needed to help to understand the porosity changes in shales.

In this study, we use the physical modeling under high temperature & pressure and X-ray nano-CT scanning data to analyze the porosity evolution with increasing maturity. Other data including nitrogen adsorption, XRD, TOC, Rock-eval and SEM observation on the same position before and after physical modeling help to find the in-situ changes with increasing maturity. The pressure in physical modeling is 80MPa and the temperature includes 300 centigrade, 350 centigrade, 450 centigrade and 550 centigrade. The sample is the low mature Chang 7 shale with type II kerogen from the Ordos basin. TOC=2.23%, Ro=0.67%, and S1=5.1mg/g

The preliminary results are as follows:

- (1) Porosity evolution is positively related to maturity according to the porosity data at different evolution stages. More and more nano-pores are developed in organic-rich shale with the maturity increasing. The porosity which is calculated from nano-CT scanning model increased from 0.56% to 2.06% when temperature increased from 20 degree C to 550 degree C.
- (2) First, porosity decreases rapidly from immature to low mature stage because of weak kerogen creaking and strong compaction. Then, porosity increases rapidly when the maturity increasing from low mature stage to oil window & gas window and abundant organic matter cracks to generate hydrocarbon (HC). Then, porosity system keeps stable when the shale enters into over-mature stage and the intensity of both HC generation and compaction decreases.
- (3) The percentage of new-created porosity in shales varies among organic matter evolution, clay mineral transformation and brittle mineral dissolution, and the ratio is 6:3:1 respectively. Abundant organic matter pores occurs when the maturity over 1.2%.

