GEOCHEMICAL CHARACTERIZATION OF K2QN1 SOURCE ROCK AND SHALE OIL RESOURCES ASSESSMENT IN NORTHERN SONGLIAO BASIN

Li Fu, Huasen Zeng

Exploration and Development Research Institute, PetroChina Daqing Oilfield Company

The Qingshankou 1st member (K_2qn^1) is the main petroleum source rock in the shallow-middle layers of northern Songliao Basin. During the deposition of K_2qn^1, the lake had high organic productivity with reduction environment at the bottom, which enhanced organic preservation. The widely spread transgression formed a vast area of thick excellent source rock. As shown in Fig. 1, microscopic review shows that there are dense lamellar algae in the K_2qn^1 shale, which are the main oil precursor. Petroleum generation kinetics analysis shows that the source rock has narrow distribution of activation energy, which is similar to the famed Green river shale. The peak oil window is therefore defined between 0.8-1.1%Ro. Oil generated by the K_2qn^1 source rock has contributed more than 40% of the whole oil potential in the Songliao Basin. Except for the expulsed oil, there are still a large amount of oil retained in the source rock, which is expected to be the main source of shale oil in this area.

The K_2qn^1 shale is a typical lacustrine excellent source rock and rich in organic carbon .The average TOC is 2.8% with the chloroform bitumen “A” of 0.421% and oil generation potential of 16.37% mg/g in average, respectively. The Chaoyangou uplift has the most abundant organic carbon with the average TOC of 3.76%, while the Changyuan uplift and Wangfu depression have less abundant organic carbon with the average TOC of 3.15%. The Heiyupao depression has the least abundant organic carbon with the average TOC of 2.05%. In contrast, the Sanzhao depression has the highest amount of chloroform bitumen “A” with the average value of 0.626%, while the Gulong depression has less amount of chloroform bitumen “A” with the average value of 0.552%. The Heiyupao depression has the least amount of chloroform bitumen “A” with the average value of 0.184%.

In order to describe the detailed organic content spatial distribution of the K_2qn^1 shale, a method using wirelog to predict organic carbon content was established. The result shows that the TOC of most K_2qn^1 shale is larger than 2.0% with the highest at ca. 4%. Based on TOC values (i.e. TOC>2.0% and TOC=0.5-1.0%), the thickness of K_2qn^1 shale was counted. The result shows that shale with TOC value larger than 2% is thicker. The thickness of shale with TOC>2.0% is in the range of 30-70m in the Center depression, while the thickness in the Sanzhao depression is 50-70m, and in the Changyuan uplift is 40-60m and in the Qijia-Gulong depression is 20-60m. The thickness of shale with TOC between 1.0-2.0% in the Center depression is in the range of 5-30m, among which the thickness in the Sanzhao depression is the least and ranges 5-15m, whereas the thickness in the Gulong depression is 15-30m and in the Qijia depression and northern Changyuan uplift is 20-30m. The shale with TOC between 0.5-1.0% has limited distribution and the thickness is generally less than 5m.

The oil content in shale can be implicated by pyrolysis free hydrocarbon S_1 or chloroform bitumen “A”, which requires compensation with light hydrocarbons lost during sampling. As the S_1 data are more available, they are used in this study to assess the oil content of shale. The S_1 content of K_2qn^1 shale in the Center depression is generally in the range of 1-4mg/g, and those with S_1>2.0mg/g are distributed in the center of Sanzhao depression, southern

Changyuan uplift, center-southern Gulong depression and the Bayanchagan area. Therefore, there is a vast area of shale with high content of oil in the northern Songliao Basin.

$$Q_{oil}= S\times H\times \rho\times (S_1 \times K_{light}+S_1\times K_{heavy} - K_{adsorb} \times TOC)$$

Where Q_{oil} is the total oil content in a shale, while S is the area, H is the thickness of the shale, ρ is the density of the shale, S_1 is the pyrolysis free hydrocarbon, K_{light} is an adjusting factor for lost light hydrocarbon, K_{heavy} is an adjusting factor for lost heavy hydrocarbon, K is the adsorb coefficient and TOC is the total organic carbon content.

Due to sampling and transporting process, light hydrocarbon content in a shale sample is usually lost before reaching a laboratory for analysis. The longer time a shale is exposed, the more gaseous content and light hydrocarbons in the shale will be lost. If a fresh shale sample is frozen before it reaches a laboratory, its S_1 content can be twice the S_1 content of the same untreated sample. Generally, source rock with different organic maturity varies in hydrocarbon composition and as the increase of organic maturity, the yielding oil has more content of light hydrocarbon. Therefore, source rock with high organic maturity tends to lose more light hydrocarbons. The adjusting factor for light hydrocarbons (i.e. K_{light}) can be established through petroleum generation kinetics analysis. It is suggested that some pyrolysis free hydrocarbons with heavy molecular weight will coelute with pyrolysis cracking hydrocarbons. Pyrolysis with chloroform extracted source rock shows that the percentage of pyrolysis free hydrocarbons with heavy molecular weight tends to decrease with the increasing organic maturity. The adjusting factor for heavy hydrocarbons (i.e. K_{heavy}) has been established based on source rocks with different maturity. Generally, the adsorbed hydrocarbons will be recovered with more difficulty and the adsorb coefficient is suggested by 100mg HC/g TOC in average.

The potential shale oil resources in the study area can be assessed by the formula mentioned above.

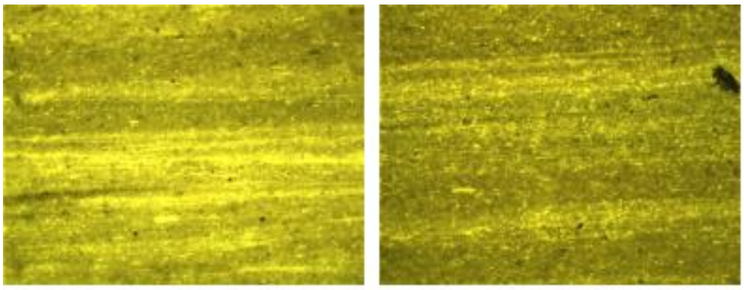

Figure 1 *The microscopic photos of lamellar algae in the K_2qn^1 shale*

References

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