New Progress in the Study of Siliceous Rock Oil and Gas in Nadanha Single Terrain

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Abstract. The siliceous shale oil and gas in Nadanhada terrane has been studied through field geological survey, geochemistry and sedimentary petrology. The results show that the area belongs to a good shale reservoir, and the siliceous rock is brittle and suitable for exploitation. The abundance of organic matter is relatively high. From west to east and from south to north, the abundance of organic matter increases and the maturity of organic matter decreases. From west to east and from south to north, the dynamic metamorphism and thermal contact metamorphism of the siliceous rocks in the Nadanhada terrane are gradually weakened, and the folds and magmatic intrusion of the strata are alleviated.

Key words. Nadanhada terrane; Siliceous rock; Organic matter abundance; Geological section

1. Introduction

The Nadanhada terrane (Wanda mountain body) is located in the eastern part of Heilongjiang Province. The Nadanhada Yanshan fold belt located in the northeast of Heilongjiang Province is distributed to the east of Dahe Zhenshen fault. Its southern section is cut off by the Mishan Dunhua deep fault. The northern and eastern sections extend out of the country and into Russia and Japan. The region is part of the Sikhot Alin hyperplastic fold system at the edge of the northwest Pacific Ocean [1]. The area in China is about $4.2\times10^6 km^2$.

Siliceous rock is a new type of hydrocarbon source rock, and there are no special evaluation standards and specifications at home and abroad. On the basis of the research on hydrocarbon generation potential of siliceous rocks last year, this year, the hydrocarbon generation capacity of siliceous rocks in Sanjiang Basin and Nadanhada terrane was reevaluated by applying the evaluation standard of continental hydrocarbon source rocks in saline water environment in China and referring to the evaluation standard of marine hydrocarbon source rocks commonly used in the world, and the organic matter abundance was raised by a grade. At the same time, light oil and asphaltene asphalt are also found in siliceous rock fractures under microscope.

2. Petrological characteristics and thickness

2.1 Fuyuan Area of Sanjiang Basin

We carried out field petroleum geological survey on siliceous rocks in Fuyuan area of Sanjiang basin, Heilongjiang border, collected paleontological and organic geochemical samples, and carried out analysis and test. The siliceous rocks and siliceous shale in Sanjiang Basin are well developed without folds and metamorphism. Horizontal bedding and massive bedding are developed. The occurrence of the stratum is completely different from that of the siliceous rocks in Nadanhada terrane in Hulin area, and its genesis may be different [2]. According to the identification of Palaeontological Laboratory of China University of Geosciences (Wuhan), the radiolaria belongs to the Early Jurassic Middle Princeton Lower Torian.

The identification results of whole rock XRD show that there are both siliceous rocks (quartz content>50%) and siliceous shale (clay>50%) in the Dajiashan Formation of Sanjiang Basin [3]. The content of brittle minerals in siliceous rocks in Sanjiang Basin ranges from 59% to 95%, with an average of 75%; The content of brittle minerals in siliceous shale is 42%, meeting the conditions for shale gas reservoir [4].

Our measured profile results show that the thickness of the lower Jurassic siliceous rock in Fuyuan profile is more than 540m (Fig. 1), and the main lithology is siliceous rock, siliceous mudstone, siliceous siltstone, radiolarian siliceous rock, etc. [5].

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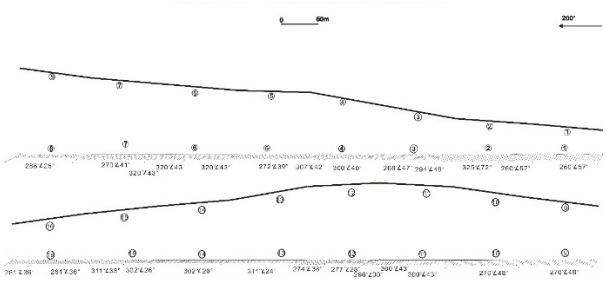

Figure 1. Measured Profile of Lower Jurassic in Fuyuan, Sanjiang Basin

2.2 Raohe region

The Dajiashan Formation (T3d -J1d) in Raohe area is developed with siliceous rocks (quartz content>50%), brittle minerals content between 75.6% and 82.5%, and the average value is 79.4%, which is very high, fully meeting the rock and mineral conditions of shale gas reservoirs. However, in the Nadanhada terrane of Raohe area, the siliceous rocks have been severely deformed and even formed sharp folds.

In conclusion, the main mineral composition of siliceous rocks and siliceous mudstones is quartz, followed by plagioclase. The content of other minerals is less than 10%, and the average content of brittle minerals is 75% and 79.4%. The brittle minerals of siliceous shale are up to 45%. Both can be used as shale gas reservoirs.

3. Organic geochemical characteristics of siliceous rocks

3.1 Organic matter abundance

3.1.1 Fuyuan District

The average content of organic carbon in siliceous rocks in Fuyuan area is 0.64%, mainly distributed in 0.07~1.89%; The hydrocarbon generation potential is 0.04-1.55 $mg \cdot g^{-1}$, with an average of 0.38 $mg \cdot g^{-1}$; The content of chloroform asphalt "A" ranges from 0.0051% to 0.0067%, with an average of 0.0059%; The total hydrocarbon value is 6~8ppm, with an average of 7ppm. According to the domestic organic matter abundance evaluation standard of continental saline ultra saline water source rock, it is a good source rock. However, due to the low content of clay minerals in siliceous rocks, which are similar to carbonate rocks and have poor adsorption capacity for organic matter, the standard of organic matter abundance should be lower than that of mudstone. According to the organic matter abundance standard of foreign marine carbonate [6], it also reaches the standard of good organic matter abundance of hydrocarbon source rocks.

3.1.2 Raohe region

The average content of organic carbon in the siliceous rocks in Raohe area is only 0.43%, mainly distributed between 0.09% and 0.81%; The hydrocarbon generation potential ranges from 0.01 to 0.07 $mg \cdot g^{-1}$, with an average of 0.04 $mg \cdot g^{-1}$; The content of chloroform asphalt "A" ranges from 0.0036% to 0.0127%, with an average of 0.083%; The total hydrocarbon value ranges from 16 to 54 ppm, with an average of 31 ppm. It belongs to the source rock with medium organic matter abundance.

3.1.3 Hongqiling region

The organic carbon content of siliceous mudstone in Hongqiling area ranges from 0.06% to 0.55%, with an average value of 0.28%; The hydrocarbon generation potential is mainly distributed in the range of 0.02~0.09 $mg \cdot g^{-1}$, with an average of 0.05 $mg \cdot g^{-1}$; The chloroform asphalt "A" is 0.007%; The total hydrocarbon is 25ppm, belonging to fair source rock.

The organic matter abundance of siliceous rocks in Nadanha terrane and Sanjiang basin is relatively high, and the hydrocarbon source rocks in Fuyuan, Raohe and Hongqiling regions reach the standard of good, medium and poor organic matter abundance respectively. The difference in the abundance of organic matter in siliceous rocks may be caused by weathering. During weathering and denudation of the source rocks, C and H elements are lost and O elements are enriched, leading to a decrease in the abundance of organic matter and a deterioration in the type [7]. In Raohe and Hongqiling regions of the Nadanhada terrane, siliceous rocks have suffered intense compression and deformation. In some places, there are even dynamic metamorphism and thermal contact metamorphism, and siliceous rocks have been lifted to the surface, It has suffered severe differentiation and denudation, so the abundance of organic matter is low. In addition, if the thermal evolution degree of the organic matter in the source rock is too high, the residual organic matter abundance can also be reduced if the organic matter in the source rock is migrated out after generating oil and gas. The organic matter maturity of the siliceous rocks in the study area is relatively high, which is currently in the high over mature stage. One reason for the low abundance of organic matter in rocks.

3.2 Types of organic matter

It can be seen from Figure 2 that most of the organic matters of siliceous rocks developed in Sanjiang Basin (Fuyuan area), Raohe area and Hongqiling area belong to Type III, and a few belong to Type II2 and Type I. However, the siliceous rocks belong to semi deep-sea facies sediments, in which the organic matter comes from radiolarians and other aquatic organisms, and the kerogen type should belong to Type I and Type II. The reason for this phenomenon is that weathering causes the loss of C and H elements in the organic matter of the source rock, the increase of O elements and the deterioration of the type, or the high maturity of the organic matter.

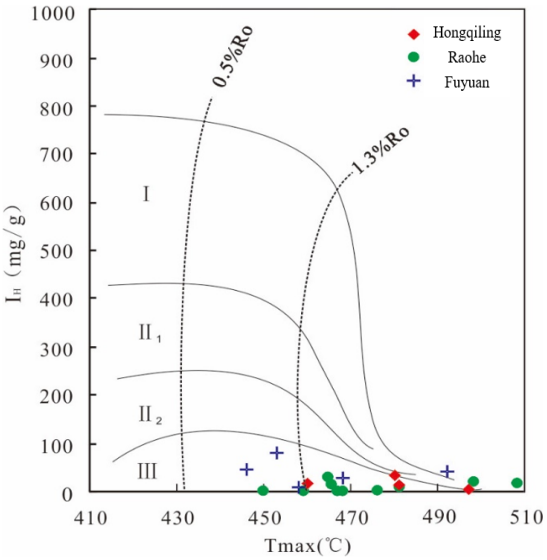

Figure 2. Organic Matter Types of Lower Jurassic Siliceous Rocks in Fuyuan, Raohe and Hongqiling Areas

3.3 Maturity of organic matter

3.3.1 Fuyuan District

In order to study the organic maturity and thermal metamorphism of siliceous rocks, Tmax, vitrinite reflectance Ro and illite crystallinity of source rocks were tested. The average Tmax of the siliceous rock in Fuyuan area is 463 ℃, which shows that the siliceous rock is in a highly mature stage, while the organic matter maturity Ro is 6.26%, which shows that the siliceous rock has reached an over mature stage, with a crystallinity CIS of 0.28~0.43 and an average IS of 0.3525. According to the relationship between the illite crystallinity index and the diagenetic stage, the siliceous rock is in a near metamorphic to non metamorphic stage.

3.3.2 Raohe region

Due to the high maturity of organic matter in the source rock, the average Tmax of the siliceous rock in Raohe area is 484 ℃, and the siliceous rock is still in the high maturity stage, with the maturity Ro of 5.7%. According to the oil and gas industry standard (SY/T 5735-1995), the siliceous rock has reached the over mature stage, with the stone crystallinity of CIS=0.39. The relationship between the crystallinity index and the diagenetic stage shows that this set of siliceous rock is in the near metamorphic to non-metamorphic stage.

3.3.3 Hongqiling region

The maturity of organic matter Ro in Hongqiling area is 2.06%, which is in the over mature stage, both at 493 ℃, and in the high mature stage. The crystallinity of lith is CIS=0.28~0.43, and the average CIS is 0.39. According to the relationship between illite crystallinity index and diagenetic stage, this set of siliceous rocks is close to the metamorphic—unmetamorphic stage

According to the three maturity indicators of each region, the siliceous rocks found in the three regions of Yuanhe, Raohe and Hongqiling are obviously in the high over mature stage, but the thermal metamorphism is relatively low, and they still have a certain hydrocarbon generation potential

4. Conclusion

It can be seen from the above that the organic matter abundance of siliceous rocks in Fuyuan area of Sanjiang basin and Raohe and Hongqiling areas of Nadanhada terrane is relatively high, reaching the standard of good, medium and poor organic matter abundance respectively; Type III kerogen is the main type of organic matter, which is currently in the high over mature stage with low metamorphic degree. However, siliceous rocks belong to deep-sea sediments, and their organic matter types should mainly be Type I and Type II, and their organic matter abundance should also be high. The test results may be caused by weathering and high thermal evolution.

In the process of field petroleum geological survey, it is found that from west to east and from south to north, the dynamic metamorphism and thermal contact metamorphism of the siliceous rocks in the Nadanhada terrane are gradually weakened, and the folds and magma intrusion of the stratum are alleviated. The organic matter and maturity of siliceous rocks are affected by dynamic metamorphism and thermal contact metamorphism. From west to east and from south to north, the abundance of organic matter increases and the maturity of organic matter decreases. The organic matter abundance of the siliceous rocks in Hongqiling area (near the Dahezhen fault, the westernmost), Raohe area and Fuyuan area (the northernmost) reaches the level of poor, medium and good respectively; Tmax is 493 ℃, 483 ℃ and 463 ℃ respectively.

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