Organic geochemical characteristics of diatomite in Nadanhada terrane

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Abstract. Based on the geochemical characteristics of the siliceous rocks in the Nadanhada terrane, the abundance, type and maturity of organic matter are studied, and the source rocks in Fuyuan, Raohe and Hongqiling are comprehensively evaluated. The type of organic matter in this area is mainly type III kerogen, which is in the high over mature stage with low metamorphic degree. At present, liquid hydrocarbon can still be produced. The Qianjin depression (Fuyuan area) of Sanjiang basin is a favorable area for the exploration of Lower Jurassic cherts with high organic matter abundance, low maturity and good preservation conditions.

Keywords: Nadanhada terrane, siliceous rock, geochemical characteristics, hydrocarbon generation, source rock.

1. Introduction
The Nadanhada terrane is mainly composed of siliceous outcrops in Fuyuan area, Raohe area and Hongqiling area. Judging from the current research indexes, it has hydrocarbon generation potential. Through laboratory tests and research at home and abroad, the geochemical characteristics are comprehensively analyzed to determine its hydrocarbon generation potential.

1.1. Abundance of organic matter in Nadanhada terrane

1.1.1. Fuyuan area. The average organic carbon content of siliceous rocks in Fuyuan area is 0.64%, mainly distributed between 0.07~1.89%; Hydrocarbon generation potential is between 0.04~1.55mg·g⁻¹, The mean value is 0.38mg·g⁻¹; The content of chloroform asphalt "A" is between 0.0051~0.0067%, The average is 0.0059%; The total hydrocarbon value is distributed in between 6~8ppm, The average is 7ppm. At present, there is no organic matter abundance evaluation standard for siliceous source rocks in China. According to the evaluation standard of organic matter abundance of continental salt water and super salt water source rocks in China, It belongs to good source rock. However, due to the low content of clay minerals in siliceous rocks, which is similar to carbonate rocks, the organic matter abundance standard should be lower than that of mudstone, according to the organic matter abundance standard of marine carbonate rocks abroad. It also reaches the standard of good organic matter abundance of source rocks.
Table 1. Organic geochemical characteristics of siliceous source rocks in Fuyuan, Raohe and Hongqiling areas

| region          | stratum | lithology       | TOC% | \( S_1+S_2/\text{mg} \cdot \text{g}^{-1} \) | Chloroform asphalt “A”% | Total hydrocarbon HC/ppm | Abundance of organic matter | \( T_{\text{max}}/\text{C} \) | \( R_o/\% \) |
|-----------------|---------|-----------------|------|----------------------------------|----------------------|------------------------|---------------------------|----------------------|---------|
| pacify a distant area | J3d     | Siliceous rock  | 0.07–1.89 | 0.64(5)good                      | 0.04–1.55 | 0.38(5)bag | 0.0051–0.0067 | 67/0.0059(2) | 6–8/7(2) | good | 446–49/2 | 463(5) | 6.26 |
| Raohe          | T3d–J1d | Chert           | 0.09–0.81 | 0.43(14)bad                      | 0.01–0.07 | 0.04(14) | 0.0036–0.01 | 27/0.0083(4) | 16–54/31(3) | medium | 450–55/6 | 484(14) | 4.74–6.3 | 5.7(3) |
| Hongqiling     | T3d–J1d | Siliceous mudstone | 0.06–0.55 | 0.28(5) | 0.02–0.09 | 0.05(5) | 0.0070(1) | 25 | bad | 460–52/5 | 493(5) | 2.06 |

Table 2. Evaluation criteria for organic matter abundance of continental source rocks

| index                  | Lake Basin water type | Non source rock | Types of source rocks |
|------------------------|-----------------------|-----------------|-----------------------|
|                        |                       | bad             | medium | good | very good |
| TOC%                   | Fresh water           | <0.4            | 0.4–0.6 | >0.6–1.0 | >1.0–2.0 | >2.0 |
|                        | brackish water        |                 |         |       |         |
|                        | Salt water            | <0.2            | 0.2–0.4 | >0.4–0.6 | >0.6–0.8 | >0.8 |
|                        | Super salt water      |                 |         |       |         |
| Chloroform asphalt “A”% | -                     | <0.015          | 0.015–0.05 | >0.05–0.1 | >0.1–0.2 | >0.2 |
|                        | HC/ppm                | <100            | 100–200 | >200–500 | >500–1000 | >1000 |
|                        | \( S_1+S_2/\text{mg} \cdot \text{g}^{-1} \) | - | <2 | 2–6 | >6–20 | >20 |

Table 3. Early oil source rock classification criteria

| Hydrocarbon generation potential | shale | carbonate rocks |
|----------------------------------|-------|-----------------|
| \( TOC \% \)                    | \( S_1 \) (mg/g rock) | \( S_2 \) (mg/g rock) |
| Poor                             | 0–0.5 | 0–0.5 | 0–0.25 | 0–0.2 |
| Fair                             | 0.5–1.0 | 0.5–1.0 | 2.5–5.0 | 0.2–0.5 |
| Good                             | 1.0–2.0 | 1.0–2.0 | 5.0–10.0 | 0.5–1.0 |
| Very good                        | 2.0–5.0 | >2.0 | >10.0 | 1.0–2.0 |
| Excellent                        | >5.0 | - | - | >2.0 |

1.1.2. Raohe area. The average organic carbon content of siliceous rocks in Raohe area is only 0.43%, Main distribution 0.09~0.81%; Hydrocarbon generation potential is 0.01~0.07mg • g\(^{-1}\); The average is 0.04mg • g\(^{-1}\); Chloroform asphalt “A” content 0.0036–0.0127%, The average is 0.083%; The total hydrocarbon content is distributed between 16~54ppm, The average is 31ppm, It belongs to the source rock with medium abundance of organic matter.

1.1.3. Hongqiling area. The organic carbon content of siliceous mudstone in Hongqiling area is between 0.06–0.55%, the average is 0.28%; Hydrocarbon generation potential is mainly distributed between 0.02–0.09mg • g\(^{-1}\), the average is 0.05mg • g\(^{-1}\); Chloroform asphalt “A” is 0.007%; the total hydrocarbon is 25ppm. They belong to fair source rocks.
It can be seen from the above that the organic matter abundance of siliceous rocks in nadanha terrane is high, and the organic matter abundance standards of Fuyuan, Raohe and Hongqiling reach good, medium and poor organic matter abundance standards respectively. The reason for the difference of organic matter abundance of siliceous rocks may be weathering. In the process of weathering and denudation, C and H elements are lost and O elements are enriched, which leads to the decrease of organic matter abundance and the deterioration of types. In Raohe area and Hongqiling area of Nadanha terrane, siliceous rocks have suffered strong compression and deformation. In some places, there are even dynamic metamorphism and thermal contact metamorphism. Siliceous rocks are lifted to the surface and suffered serious differentiation and erosion, so the organic matter abundance is low. In addition, if the thermal evolution degree of organic matter in source rock is too high, the organic matter in the source rock generates oil and gas and migrates out, which can also lead to the low abundance of residual organic matter. The organic matter maturity of siliceous rocks in the study area is relatively high, and it is in the high over mature stage. This is also a reason for the low abundance of organic matter in siliceous rocks. In any case, siliceous rock is a special set of source rocks, which belongs to a new field of strategic constituency research.

1.2. Organic matter types of Nadanha terrane

It can be seen from Figure 1 that most organic matter types of siliceous rocks in Fuyuan area, Raohe area and Hongqiling area in Sanjiang Basin belong to type III, and a few belong to type II 2 and type I. However, the siliceous rocks belong to the semi deep sea deep sea facies, and the organic matter in them comes from the aquatic organisms such as radiolarians. 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 organic matter of source rocks, the increase of O elements and the deterioration of their types. Or the maturity of organic matter is too high, and the C and H elements in kerogen are reduced by hydrocarbon generation and expulsion.

![Fig. 1 Organic matter types of Lower Jurassic siliceous rocks in Fuyuan, Raohe and Hongqiling areas](image)

1.3. Maturity of organic matter in Nadanha terrane

1.3.1. Sanjiang Basin (Fuyuan area). In order to study the maturity of organic matter and thermal metamorphism of siliceous rocks, the characteristics of source rocks were measured Tmax, Vitritine reflectance Ro And illite crystallinity.Siliceous rocks in Fuyuan area Tmax The average is463 ℃, It shows that the siliceous rocks are in the high mature stage, while the organic matter is mature Ro is 6.26%, It shows that the siliceous rock has reached the over mature stage;Illite Crystallinity CIS=0.28~0.43, CIS The average is 0.3525, According to the relationship between illite crystallinity index and diagenetic stage, The siliceous rocks are in the near metamorphism - unmodified stage. The homogeneous temperature of the fluid inclusions of the lower Jurassic siliceous rocks is 195.4 ℃, which is in the high mature stage.
1.3.2. Raohe area. It can be seen from table 5.1.2-4 that the organic matter maturity of siliceous source rocks is high, and the average Tmax of siliceous rocks in Raohe area is 484 °C, and the siliceous rocks are still in high maturity stage; however, the maturity of organic matter ro is 5.7%, according to the oil and gas industry standard (SY / T) According to the relationship between illite crystallinity index and diagenetic stage, the siliceous rocks are in the near metamorphism and non metamorphism stage.

2. Conclusion

The type of organic matter in the Nadanhada terrane is mainly type III kerogen, which is in a high over mature stage with a low degree of metamorphism.

The abundance of organic matter of siliceous rocks in Fuyuan area, Raohe area and Hongqiling area in Nadanhada terrane reaches good, medium and poor levels respectively, and Tmax values are 463 °C, 483 °C and 493 °C. The Qianjin depression (Fuyuan area) of Sanjiang basin is a favorable area for the exploration of Lower Jurassic cherts with high organic matter abundance, low maturity and good preservation conditions.

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