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Evaluation of Deep Source Rocks in Shuangliao Fault depression of Songliao Basin

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Abstract: In order to understand the hydrocarbon generation potential of deep source rocks in Shuangliao fault depression, the distribution characteristics of hydrocarbon source rocks were predicted based on the core data, logging curve and seismic data. Combined with chemical analysis, thin section identification and other data, the abundance, type and maturity of hydrocarbon source rocks in Shuangliao fault depression were analyzed systematically. Research shows that the deep Shuangliao fault depression mainly developed three sets of hydrocarbon source rocks, Huoshiling formation, Shahezi formation and Yingcheng formation, their distribution is controlled by the N-S treading controlling-depression faults in the plane, is thicker in the west and thinner in the east. Deep source rocks in Shuangliao fault depression has an middle organic matter abundance, type is mainly II $_2$and III , and is on the thermal evolution stage from mature to high mature, and is conductive to generation of natural gas.

I. INTRODUCTION

With the rapid development of China's economy, the demand for oil and gas resources has become increasingly urgent. As a low exploration degree fault depression[1], the hydrocarbon generation of deep source rocks in Shuangliao fault depression has been lack of evaluation. With the continuous exploration and accumulation of data in Jilin oilfield, it is necessary to evaluate the hydrocarbon source rocks of Shuangliao fault depression systematically.

II. REGIONAL GEOLOGY OF SHUANGLIAO FAULT DEPRESSION

Shuangliao fault depression is located in the southwest of the Southeast Uplift in Songliao Basin [2], which east is Lishu fault depression and the north is Changling fault depression. It is a secondary structure unit of southern Songliao basin with a total area about 1280km^2.

The sedimentary strata of Shuangliao fault depression including Huoshiling formation, Shahezi formation, Yingcheng formation, Denglouku and Quantou formations of Lower Cretaceous from bottom to top; Upper Cretaceous including Qingshankou formation, Yaojia formation, Nenjiang formation, Sifangtai formation and Mingshui formation; Yian formation belong to Paleogene, Da'an formation and Taikang formation included in Neogene and etc.[3-4]. Among them, the deep source rocks are mainly lacustrine facies mudstone of Yingcheng formation, Shahezi formation and Huoshiling formation.

III. DISTRIBUTION CHARACTERISTICS OF HYDROCARBON SOURCE ROCKS

Seismic and drilling data show that there are three sets of hydrocarbon source rocks in Shuangliao fault depression including Yingcheng formation, Shahezi formation and Huoshiling formation. These three sets of hydrocarbon source rocks are controlled by the N-S treading controlling-depression faults in the plane, which gradually thinning from the west to east. Through the mudstone thickness has been drilled, the development of mudstone in the Shuangliao fault depression is not balanced in the vertical direction. According to the drilling results, the average thickness of dark mudstone in Huoshiling formation is135.1meters, which accounted for 23.1% of average formation thickness; the average thickness of dark mudstone in Shahezi formation is 165.5m, which accounted for 35.8%; the Huoshiling formation is 204.8m, which is 38.5%.

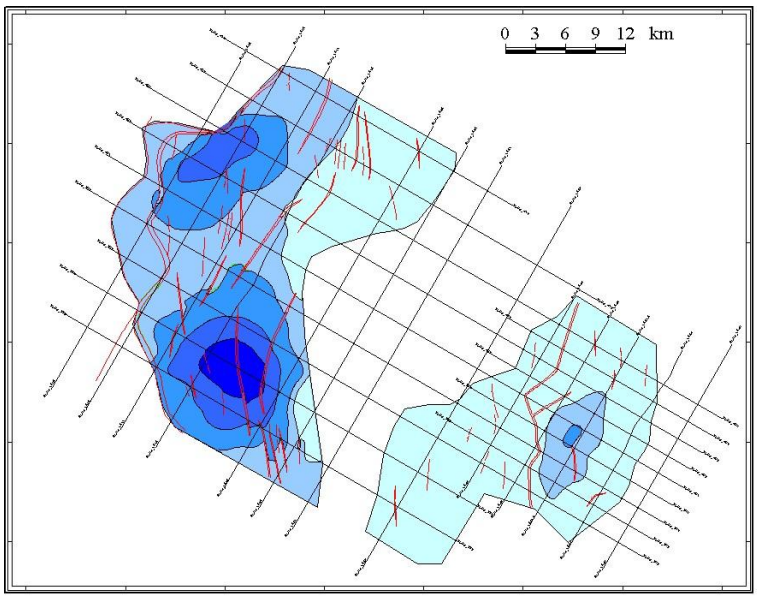


Fig 1 The thickness of deep dark mudstone in Shuangliao area

IV. GEOCHEMICAL CHARACTERISTICS OF HYDROCARBON SOURCE ROCKS

The qualitative evaluation to source rocks is not only the important foundation for evaluation of hydrocarbon source rocks, but also the macro evaluation of source rocks quality during early exploration[5], which mainly include the aspects of organic abundance, type and organic matter maturity [6-7].

3.1 Organic matter abundance

About 491 samples got from 5 exploratory wells and appraisal wells that drilled into deep source rocks in Shuangliao fault depression were analyzed using organic geochemical characteristics. Based on the TOC index, the TOC value of Huoshiling formation is distributed in 0.04~5.67%, the TOC value of Shahezi formation is distributed in 0.39~5.18%, the TOC value of Yingcheng formation is distributed in 0.15~4.23%, and the average values are 0.95% , 2.21% and 0.89%; the S_1+S_2 value of Huoshiling formation is distributed in 0.24~8.73 mg/g, the S_1+S_2 value of Shahezi formation is distributed in 0.39~5.18 mg/g, the S_1+S_2 value of Yingcheng formation is distributed in 0.15~4.23 mg/g, and the average values are 2.06 mg/g, 5.36 mg/g and 2.45 mg/g; the Chloroform Bitum "A" value of Shahezi formation is distributed in 0.01~0.15%, the Chloroform Bitum "A" value of Yingcheng formation is distributed in 0.10~0.23%, and the mean values are 0.08% and 0.17%; the Ro value of Shahezi formation is distributed in 1.14~2.02%, the Ro value of Yingcheng formation is distributed in 1.29~1.6%, and the average values are 1.65% and 1.47%.

Table 1 Organic geochemical analysis data of deep source rocks in Shuangliao fault depression

source rock	thickness（m）	TOC（%）	S1+S2（mg/g）	Chloroform Bitum "A"（%）	Ro（%）
Yingcheng	57.0~584.1	0.15~4.23	0.07~12.73	0.10~0.23	1.29~1.6
group mudstone	204.8(5)	0.89(225)	2.45(57)	0.17 (13)	1.47(5)
Shahezi group	23.1~435.7	0.39~5.18	0.01~23.87	0.01~0.15	1.14~2.02
mudstone	165.5(5)	2.21(212)	5.36(120)	0.08(26)	1.65(40)
Huoshiling	7.0~170.6	0.04~5.67	0.24~8.73		
group mudstone	135.1(3)	0.95(23)	2.06(14)		

Note: the data in the table are (minimum ~ maximum value) / mean value (number of samples).

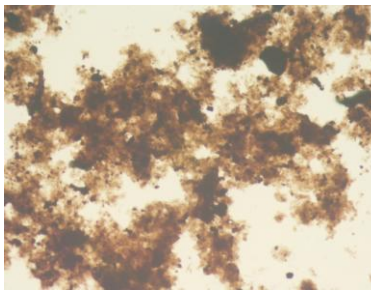
On the whole, the organic matter abundance of deep source rocks in Yingcheng and Shahezi formation of Shuangliao fault depression is better than which in Huoshiling formation, most of them in the middle level and above. Yingcheng formation and Shahezizu formation. From the histograms of organic matter, the hydrocarbon potential of Yingcheng formation and Shahezi formation is higher, and the organic matter abundance is in medium level or even higher. Therefore, the deep source rocks of Shuangliao fault depression should be good gas source rocks.

3.2 Organic matter type

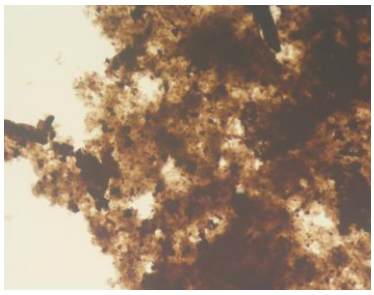
Kerogen is mainly composed of two parts under the microscope, one is organic detritus with special

morphology and structure features which component and source can be identified and only accounts for a small part; the other one is cellular non-crystalline matrix without structure and constant form. Using the kerogen microscopic detection technology, we can identify the organic micro composition of kerogen directly and learn the biological source even determine the type.

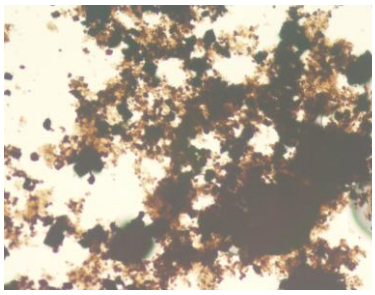
The microstructure and organic element composition of 12 samples of 5 exploratory wells show that the kerogen type is mainly Ⅱ_2 and Ⅲ in Shuangliao fault depression. From the macerals (figure 3), Shuangliao fault depression has a higher vitrinite content, the organic matter is humus type closed to sapropel, type is medium. From the paradigm figure, the kerogen type of Yingcheng formation is mainly Ⅱ_2, Shahezi formation is Ⅱ_2, but it is already close to type Ⅲ. Therefore, the source rocks in Shuanglian fault depression double are propitious to generation of gas.



Well of Shuang X , 2591m, black mudstone, Ⅲ



Well of Shuang X , 2865m, black mudstone, Ⅱ2



Well of Shuang X , 3376m, black mudstone, ⅠII

Fig 2 Micrograph of kerogen types of deep source rocks in Shuangliao fault depression

3.3 Organic matter maturity

It needs a long time for organic matter to generate oil and gas under the action of temperature and a series of changes after it deposited. Time and temperature are two important actors in the serious of changes. Ro is a significant parameter that measuring the degree of changing because of the stable changing rules corresponding to the geothermal and relative wide & stable comparability.

More than half of the samples in Yingcheng and Shahezi formations of Shuangliao fault depression achieve the good and very good level with the kerogen type of Ⅱ2 and Ⅲ mainly. According to the result of qualitative evaluation of source rocks, we can clearly know that the thermal evolution stage of Yingcheng formation is mature stage from 1700m, and the Shahezi formation is high mature from 2800m.

V. CONCLUSION

1. There are three sets of hydrocarbon source rocks in Yingcheng formation, Shahezi formation and Huoshiling formation. These three sets hydrocarbon source rocks are controlled by the controlling-depression faults in the plane, which gradually thinning from the west to east.

2. The organic matter abundance of deep source rocks in Yingcheng and Shahezi formations of Shuangliao fault depression is at a middle level; the main type of kerogen are Ⅱ_2 and Ⅲ; the organic matter maturity is on the thermal evolution stage from mature to high mature, and is conductive to generation of natural gas.

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