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Sunwu-Jiayin Basin Petroleum Geological Characteristic and Favorable Area Prediction

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Abstract

For researching the petroleum geological characteristic of Sunwu-Jiayin basin and predicting the favorable zone and supplying scientific evidences of the next oil and gas exploration and development, it combines the nearest drilling consequence and data explanation result of seismic exploration ,researches the overall petroleum geology. The outcome shows that the source-reservoir-cap combination of Xunke-zhanhe sag Taoqihe formation develops so well to favor the oil-gas generation and accumulation. ZH No1 fault No1 fault anticline is the most favorable prospect for drilling.

Keywords: Sunwu-Jiayin basin, lower cretaceous series, petroleum geological condition, petroleum prospect.

1. Introduction

Recent years, with the increasing difficulty of oil-gas exploration and development, low-degree exploration basins are getting more and more extensive concern and attention.Sunwu-Jieya basin across China and Russia have a total area of $7.5102\times10^4 km^2$.Commercial oil and gas flow has been found in Russia. The area of Sunwu-Jiayin basin in china is $22810km^2$, possessing the similar geological characteristic and the condition of reservoir formation .but in the preceding process of exploration, Sunwu-Jiayin basin never found the indication of oil and gas.In the Xunke-zhanhe sag Taoqihe formation,Jia 1 well drilled recently found above the average is hydrocarbon source rock, it shows that Sunwu-Jiayin basin possess good exploration prospect. this article trying to base on the nearest drilling consequence and reinterpreted seismic data, further researches the petroleum geological characteristic of this basin, predicts the favorable zone, offers scientific evidences of the next oil and gas exploration and development.

2. Regional geological survey

Sunwu-Jiayin basin is located in the north part of Heilongjiang province and covers an area of $22,810km^2$.The area of Sunwu-Jiayin basin borders on the west of Zhangguangcai ridge fold belt and the east of Daxinganling ridge fold belt. The basin goes to Russia across the Heilong River from the north side, and it closes to Song Liao basin from the south side. It develops continental deposit in the basin. from west to east, Sunwu-Jiayin basin can be divided to five primary structural units: Sunwu depression、Maolanhe uplift、Zhanhe depression、Furao uplift、Jiayin depression (fig 1)(Li Xiaojuan,2010). in the middle of the basin Zhanhe depression has a area of 7180 km^2,primly developed lower cretaceous series Taoqihe formation,is the biggest intact depression in Sunwu-Jiayin basin.

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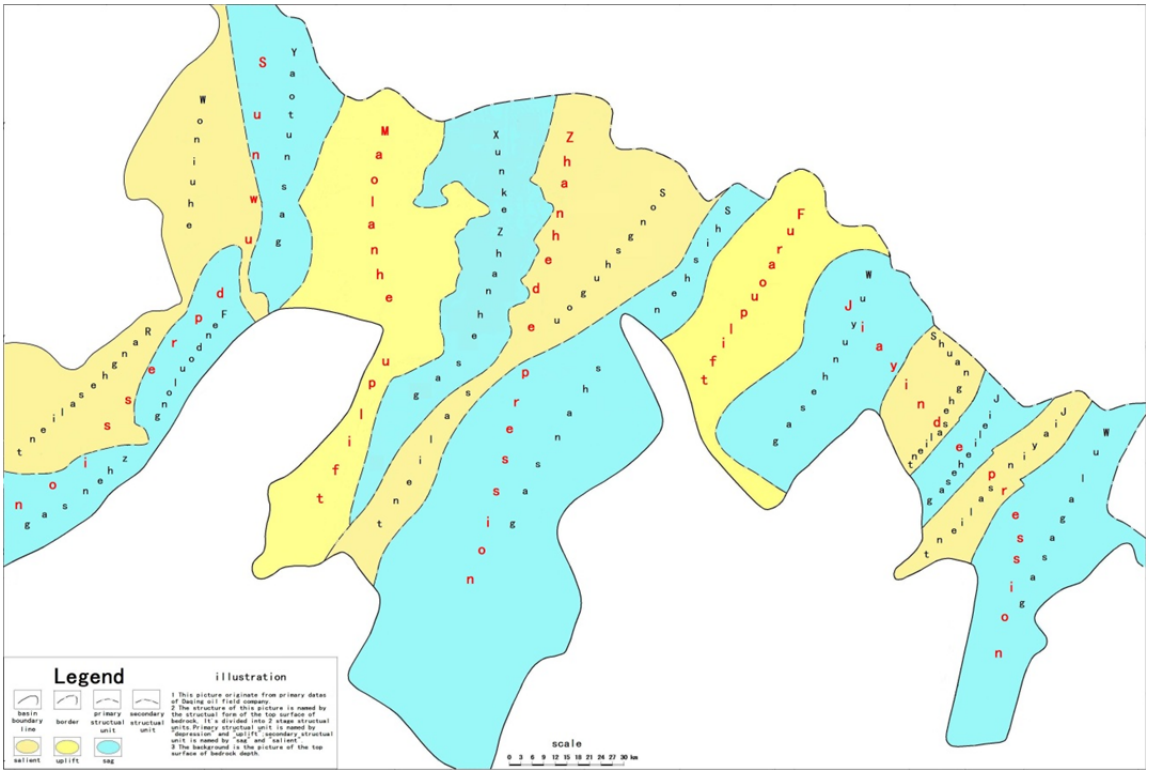

Fig.1. The map of Sunwu-Jiayin basin structure unit (Daqing oil field exploration department, 2010)

The basement of basin is consisted of Paleozoic Erathem metamorphic rocks and Variscan granite.In Mesozoic Erathem from down to up it developed orderly lower cretaceous series Ningyuancun formation(K_{1n})and Taoqihe formation(K_{1t}),upper cretaceous series Yongancun formation(K_{2y}) 、Taipinglinchang formation(K_{2t})(fig 2).The period of Taoqihe formation deposit is the mainly developing time of basin rifts, its sedimentary facies are mainly lakebed fan facies、deep lake and semi-deep lake facies、fan-delta front facies、shallow lake facies,its source、reservoir、cap developed well,it is the major explanation interest layers of Sunwu-Jiayin basin. Taoqihe formation has the thickest deposit in Zhanhe depression, from west to east the deposit goes thicker and from south to north it goes thinner, the biggest thickness of deposit can be 2300m.lower formation is mainly conglomerate and glutenite, more or less gravel sandstone and mudstone, bottom formation has tuff. Middle and upside formation is dark mudstone and silty mudstone and fine sandstone coal.

3. Petroleum geological characteristic

3.1 Hydrocabon source rock

Hydrocarbon source rock take the most significant part of six reservoir formation factors, is the essential condition of oil and gas reservoir formation.

3.1.1 The lithology and depth of hydrocarbon source rock

Sunwu-Jiayin basin Taoqihe formation developed dark mudstone well, is the major hydrocarbon source rock formation, Taoqihe formation in Zhanhe depression has the biggest depth of Hydrocarbon source rock, it can be 1150m and the biggest single layer is 37m;Sunwu depression is thinner to be 700m；Jiayin depression is the thinnest to be 120m.the favorable hydrocarbon source rock development phase

zone of Sunwu depression、Zhanhe depression、Jiayin depression is separately 830 km^2、 559 km^2、499 km^2.

Based on the constrained inversion mudstone prediction and the analysis of organic geochemical, Taoqihe formation in Zhanhe depression developed best,settled down the substance foundation for the oil and gas generation and enrichment in the basin. Sunwu depression、Jiayin depression is hard to form large scale of hydrocarbon source rock because of the shallow depth of burial.

3.1.2 Organic matter abundance

Taoqihe formation is the main force of hydrocarbon source rock development layers in Sunwu-Jiayin basin; organic matter abundance is relatively high. according to petroleum and natural gas industry standards of the people's republic of china SY/T5735-1995(Huang Fei and Xin Maoan,1996),the organic matter abundance of most samples achieve the medium to best standard of hydrocarbon source rock.The organic matter abundance in each layers is different more or less, the organic matter abundance of hydrocarbon source rock in Taoqihe formation is the highest(Table 1),TOC is mainly distributed in 0.21~4.98%,the average is 1.89%；the distributed scope of chloroform bitumen"A"is 0.39~11.69%,the average is 2.61%；the scale of S_1+S_2 is 0.045~20.468mg/g,the average is 2.94mg/g；total hydrocarbon content is between 46.3~80.39 mg/g, the average is 61.66 mg/g(Table1).

Table.1. Sunwu-Jiayin basin formation hydrocarbon source rock evaluation form

Formation	TOC(%)	Chloroform bitumen A(%)	S1+S2(mg/g)	Total hydrocarbon(mg/g)	Evaluation
Taipinglinchang	0.51~1.13 0.89(7)	0.0071~0.019 0.0128(5)	0.31~0.94 0.55(7)		bad
Yongancun	0.16~4.51 1.33(23)	0.0045~0.0348 0.0139(12)	0.06~22.48 2.63(21)	54.41~76.86 61.89(3)	medium
Taoqihe	0.21~4.98 1.89(171)	0.0039~0.1169 0.0261(49)	0.045~20.468 2.94(171)	46.3~80.39 61.66(13)	good
Ningyuancun	0.10~5.93 1.72(23)	0.0047~0.0451 0.0249(2)	0.024~14.01 2.31(5)		medium

3.1.3 Organic matter type

Sunwu-Jiayin basin is continental facies deposit lake basin, in the hydrocarbon source rock there are land source organic matters and lake facies aquatic, organic matter type is mainly humic-sapropel Ⅱ and sapropel Ⅲ(fig 2),possesses the relatively high oil and gas generation potential.

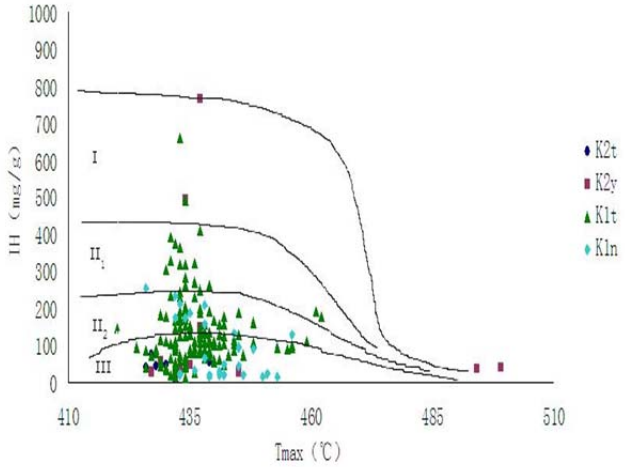

Fig.2. Sunwu-Jiayin basin hydrocarbon kerogen type division fig

3.1.4 Organic matter maturity

Organic matter maturity of hydrocarbon source rock is the key of oil and gas generation, it determines the possibility of oil and gas generation by the hydrocarbon source rock and the phase state of generated hydrocarbon. the test result of hydrocarbon source rock revealed by the nearest drilling consequence indicates that hydrocarbon source rock in Sunwu-Jiayin basin has accessed the oil generation threshold since 650m,begain to generate oil and gas; it has accessed mature phase of large amount hydrocarbon generation at 1120m;when at 2080m,Ro=1.0% more or less,it reaches the top of oil generation.

The hydrocarbon source rock at Taoqihe formation is mainly between lower mature to mature phase right now(fig 3),most samples of Ro is between 0.5% to 1.3%,minimum is 0.45%,maximum is 1.3%.

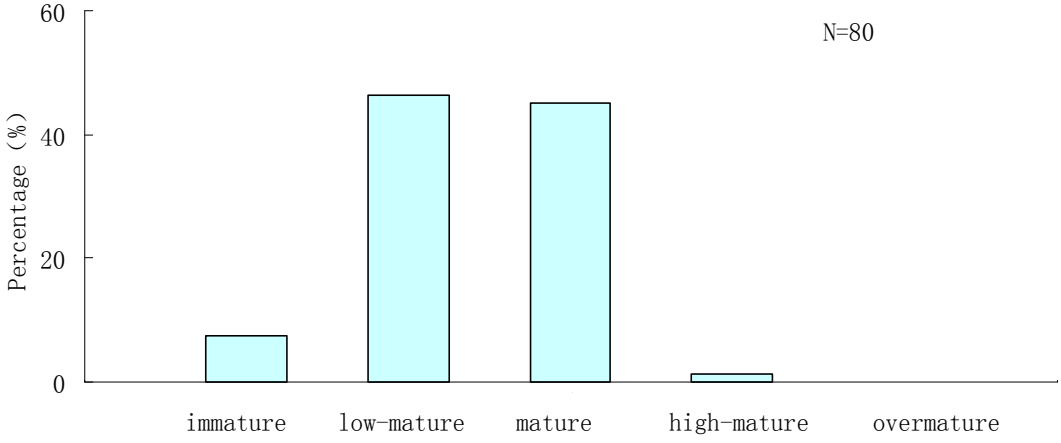

Fig.3.Sunwu-Jiayin basin hydrocarbon source rock Ro fig

3.2 Reservior

Reservoir in Sunwu-Jiayin basin mainly develops at lower cretaceous series Taoqihe formation,has a

relatively bigger single layer(Table 2).Litho logy is mainly coarse clastic rocks, the component of reservoir rock is mainly feldspar clastic rock and debris feldspar sandstone, quartz content is from 12% to 44%,the average is 27%；feldspar content is from 18% to 41%,the average is 31%；debris content is from 5% to 56%,the average is 32%.matrix content is from 3% to 8%,the average is 4%.sepration is medium, psephicity is poor-medium. Physical properties are relatively good. physical properties have a drop trend effected by the compaction with the depth increasing(Holditch ,2006；Bjørlykke , 2010；Feng Zengshao,2013；).the average of sandstone porosity is 20.4%;the average of permeability is 23.14×10-3μm^2,according to petroleum and natural gas industry standards of China(Zhao Chenglin,1997),overall it belongs to medium porosity and low permeability reservoir. Pore types are mainly primary intergranular pores and intergranular solution pore. Ro is mainly between 0.5 to 1.3%, clastic rock reservoir is in the phase of medium A diagenesis.

Table.2.Sunwu-Jiayin basin sandstone thickness

Formation	maximum Single layer thickness(m)	Total thickness(m)	Formation thickness(m)	Sandstone thickness ratio(%)
Taipinglinchang	39.6	268	635	42.2
Yongancun	8.8	402	548	73.4
Taoqihe	60	470	1723	27.3
Ningyuancun	75	495.2	872	56.8

3.3 Cap

In Sunwu-Jiayin basin the Ro of mudstone is mainly distributed between 0.5-1.3%,hydrocarbon source rock is in liquid window.Mudstone cap in this maturity phase possess the ability of capillary cap and hydrocarbon concentration cap simultaneously, mud plasticity is relatively big in the medium diagenesis phase, cap rock is medium-good, preservation condition is relatively good(Pang Weiqi,1993).the accumulated thickness of cretaceous argillaceous is over 1000m,single layer thickness can be 30～40m,it can form relatively good sealing cap condition in the inner cretaceous. Taoqihe formation、Yongancun formation and Taipinglinchang formation consist three sets of regional cap in the depression, it preserved relatively good, most of fault are stopped in Taoqihe formation. These three sets all develop mudstone, it mainly is Lake Facies deposit in the end of deposit, mudstone has a widespread area and a certain thickness, it can be a good regional cap in the basin. The drilling result of Jia 1 well in the middle of basin Xunke-zhanhe sag indicate that the accumulation mudstone thickness of Taoqihe formation is 1150m,maximum single layer thickness is 37m, the accumulation mudstone thickness of Yongancun formation is 70m,the accumulation mudstone thickness of Taipinglinchang formation is 60m,I predict that mudstone should developed better in the center of deposit.

3.4 Trap condition

Seismic interpretation result indicates that the trap types of Sunwu-Jiayin basin mainly are faulted anticline and fault nose structure and stratigraphic lithologic traps. Until now in sag the number of structural traps and lithologic traps found is 17, total area of traps is 1029.37km^2, the maximum trap area is 311.44 km^2.

Trap has the trait of long-term successive development,most traps had their embryonic shape in early cretaceous epoch, shaped eventually in the phase of late cretaceous epoch Taoqihe formation upper.

3.5 Hydrocarbon migration

According to the theory of hydrocarbon expulsion threshold(Pang Weiqi,1995),the depth of hydrocarbon expulsion threshold calculated in Sunwu-Jiayin basin is 1100m,the corresponding Ro is 0.7%.form the geothermal history (fig 4) we can see that No.1 section of Taoqihe formation($K1_{tq1}$)and No.2 section of Taoqihe formation($K1_{tq2}$)separately enter hydrocarbon expulsion threshold(Ro=0.7%) at the deposit period of No.2 section of Taoqihe formation($K1_{tq2}$)and Taipinglinchang formation($K2_{tp}$),began to expulse hydrocarbon. Sunwu-Jiayin basin mainly develops stratigraphic traps and anticline traps, stratigraphic traps formed relatively early, anticline trap has the trait of long-term successive development, it shaped eventually at the deposit period of upper Taoqihe formation. The time of hydrocarbon migration isn't later than trap formation, they have good match relationship, that's the reason why hydrocarbon generated in Sunwu-Jiayin basin can form reservoir at the end of early cretaceous epoch.

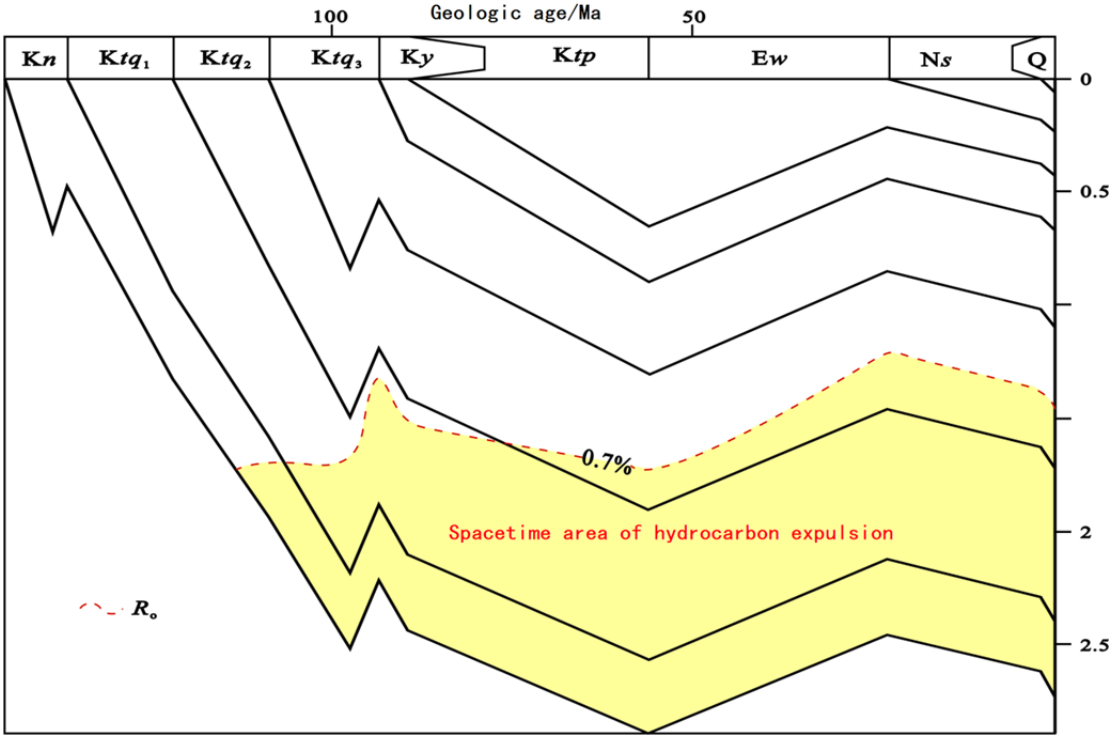

Fig.4. The geothermal history of Jia 1 well in Sunwu-Jiayin basin

3.6 Hydrocarbon preservation

Although in geological history, Sunwu-Jiayin basin occurred uplift erosion, but the semi-deep lake facies relatively thick mudstone at the upper Taoqihe formation preserve the intactness of traps. Xunke-zhanhe sag Taoqihe formation has the best preservation condition,Sunwu depression Taoqihe formation is worse,Jiayin depression Taoqihe formation is worst.

4. Favorable area prospect

The most favorable zone of oil and gas accumulation is Xunke-zhanhe sag in Zhanhe depression, which in the middle of Sunwu-Jiayin basin has the biggest area of about 1920 km^2 among all sags in the basin and the biggest depth of burial is 3350m.it is formed by some syncline and nose structures. The condition of source-reservoir-cap combination in Xunke-zhanhe sag is best, hydrocarbon source rock

developed well and has a relatively high maturity, the thickness of hydrocarbon source rock in Taoqihe formation normally is 200-1000m,the ,the biggest thickness can be over 1100m, in the deposit period of Taoqihe formation lake facies developed well in the middle of sag,it's in favor of hydrocarbon source rock development. fan-delta facies developed well around, the overlying Yongancun and Taipinglinchang formation developed lake facies and delta facies,it can provide good reservoir and cap. The psephicity condition of reservoir and cap is relatively good; it supplies the possibility for hydrocarbon migration and preservation as the favorable condition for reservoir formation of hydrocarbon in this area. there is a relatively high degree of exploration, the density of survey line is basically 2×4km and there are 1 geological well and 1 exploratory well. the structure is confirmed, there are fault anticline structure in the sag, it have been found some structural traps limited by strata pinch-out line and some structural traps and stratigraphic traps in the west side of the sag, it has the possibility of forming structural reservoir. ZH No1 fault No1 fault anticline is the relatively favorable structural belt.

5. Conclusion and proposal

(1)Sunwu-Jiayin basin developed source-reservoir-cap combination well, possesses abundant oil and gas resource and the formation condition of oil and gas reservoir；

(2)in Sunwu-Jiayin basin the formation time of traps and the hydrocarbon expulsion match well, it's favorable for the formation of oil and gas reservoir；

(3)Xunke-zhanhe sag is the most favorable area of oil and gas accumulation in Sunwu-Jiayin basin,ZH No1 fault No1 fault anticline is the most favorable prospect for drilling.

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