A study on the Identification of Jurassic paleo-oil reservoirs in the Mosuowan uplift, Junggar Basin

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Abstract. At present, some small to medium-sized oil and gas reservoirs have been discovered in Jurassic Lower Sangonghe Formation (J₁s). Previous studies speculated that the Mosuowan uplift was an important gathering area for oil and gas migration during the middle and late Jurassic, and it had a large-scale oil accumulation. Due to the southern dipping of the basin during the Himalayan Period, the paleo-oil and gas reservoirs formed in the Mosuowan uplift in the early stage migrated from the south to the north and re-accumulated. In this paper, the grain fluorescence technique was used to measure the fluorescence intensity of hydrocarbons and free hydrocarbons in the particles of the reservoir by laser scanning analysis. The fluid stratigraphy analysis technique was used to remove the free natural gas and light hydrocarbons in the reservoir sandstone by vacuum desorption. The two techniques combined with gas measurement of total hydrocarbons, geochemical parameters and oil test results, identify the height of the ancient oil column, and clarify that most of the wells exist in the exploration layer. But the height of the column is generally small, and most of the single layers are less than 20m, indicating that the Mosuowan uplift does not form a broad-cover type of oil and gas reservoir. Most wells don’t have obvious ancient oil columns.

1. Introduction
The amount of the remaining resources in the abdomen of the Junggar Basin is very large. Some small to medium-sized oil and gas reservoirs have been recently discovered in the Lower Jurassic Sangonghe Formation (J₁s). Compared with the scale of oil and gas reservoirs found on the northwestern margin of the basin, the Mosuowan uplift has been found that the size of the reservoir is not proportional to the hydrocarbon expulsion of the source. Many scholars have speculated that the Chemo ancient uplift has an important controlling effect on hydrocarbon accumulation (Dengfa He et al. 2008). During the Middle and Late Jurassic, the Mosuowan uplift was an important gathering area for oil and gas migration, and there was a large-scale oil accumulation. During the Himalayan period, due to the rapid subsidence in the southern part of the Junggar Basin, it existed a large-scale oil and gas migration and re-accumulation process from south to north, and paleo-oil reservoir of early in Mosuowan uplift migrated along the beam. They adjusted the movement to the Luliang uplift and then accumulated. The height of the ancient oil column in the Mosuowan area is high, and the size of the ancient oil reservoir is large. There is not enough evidence to explain it, and it needs to be confirmed by some researches. In this paper, quantitative fluorescence technique and fluid inclusion stratigraphy

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FIS analysis technique were used to analyze the typical fossil record of the Mosuowan uplift and identify and characterize the size of the ancient reservoir.

2. Survey of work area

The Mosuowan uplift anticline is located in the middle of the Mosuowan uplift in the central depression of Junggar Basin. It is one of the most advantageous exploration prospects in the abdomen of the basin. Six most important hydrocarbon-generating depressions are adjacent to the Mosuowan uplift. The Mosuowan uplift area has complete stratigraphic development, and they are Carboniferous, Permian, Triassic, Jurassic, Cretaceous and Cenozoic from bottom to top. The uplift is distributed in the northwest direction. The Upper Carboniferous-Permian Xiazijie Formation is missed from the high part of the uplift, and the Lower Wuerhe-Kelamayi Formation is covered by the uplift. During the deposition period of the Baijiantan Formation - Badaowan Formation, the uplift disappeared. The Sangonghe, Xishanyao and Toutunhe Formation are remnant distributed in this area, showing the northeastward residual distribution belt. The Mosuowan uplift area has different tectonic and sedimentary features in different periods. only till the Himalayan period, due to the formation of the regenerative foreland basin in the southern margin, the regional instability of the entire basin occurred to the south, which made the Mosuowan uplift have the characteristic of a slope from north to south.

The sand body of the Sangonghe Formation of the Jurassic in the Mosuowan uplift is developed with large thickness and stable lateral distribution. It is mostly medium hole and medium to low permeability reservoirs with good reservoir conditions. Both the drilling and logging data show oil and gas, indicating that there has been oil and gas migration and accumulation in the area, but the oil test results are mostly high-yield water layers. Based on previous studies, this paper applies quantitative fluorescence technique and fluid inclusion stratigraphy technology to analyze the core and cuttings samples of the Jurassic in the Mosuowan uplift. The ancient oil column interval in the typical exploration well is used to determine the height of the ancient oil column and the size of the ancient oil reservoir.

3. Experimental methods and experimental samples

3.1 Principles and main parameters of quantitative fluorescence technology

In this paper, two kinds of fluorescence techniques are mainly used to study oil-containing inclusions: QGF (Quantitative Grain Fluorescence), sand samples are sorted, and washed by a series of chemical reagents, followed by determination in a Varian fluorescence spectrophotometer. The relative content of oil-containing inclusions in sand grains; QGF-E (Quantitative Grain Fluorescenton Extract) refers to the relative content of oil-containing organic matter on the surface of sand grains measured by physical and chemical treatment in a Varian fluorescence spectrophotometer. The method uses ultraviolet excitation waves of 254 nm and 260 nm, and records a continuous emission spectrum of 300 to 600 nm. The fluorescence detection and analysis method can avoid the complicated and cumbersome separation procedure, and has the advantages of high sensitivity, good selectivity, small sampling amount, fast analysis speed, and no damage of the sample. In this paper, particle quantitative fluorescence and quantitative fluorescence of particles are used to determine the present residual oil and paleo-oil column in oil and gas reservoirs.

The main fluorescence parameters are used. Imax means maximum peak intensity. 1300nm means peak intensity at 300nm. QGFindex means the ratio of the average fluorescence intensity from 375nm to 475nm to the fluorescence intensity at 300nm, expressed as:

$$QGF\text{Index}(Q_1) = \frac{I_{375nm} - I_{475nm}}{I_{300nm}}$$

$\lambda_{\text{max}}$ means maximum peak wavelength, which is at maximum fluorescence intensity. Delta Lambda means wavelength corresponding to half-peak height. QGF ratio means average fluorescence intensity from 375 nm to 475 nm, the ratio of fluorescence intensity at 350 nm is expressed as:
QGFIndex\( (Q_1) \) = \frac{I_{375\text{nm}}}{I_{475\text{nm}}}/I_{350\text{nm}} \quad (1-2)

QGF-E intensity means the maximum peak intensity obtained by normalization to 1 g of quartz sand in 20 ml of dichloromethane solvent. Lam1 \( \lambda_1 \), the particle’s fluorescence intensity is the smaller wavelength corresponding to half of the maximum fluorescence intensity, which is \( \lambda_1<\lambda_2 \); Lam2 \( \lambda_2 \), the larger wavelength of the particle fluorescence intensity corresponding to half of the maximum fluorescence intensity, which is \( \lambda_2>\lambda_1 \).

3.2 Fluid inclusion stratigraphy technology
Fluid Inclusion Stratigraphy (FIS) can form chemical scanning analysis data of whole well formation fluids. The FIS technical analysis object is to assign below C_8 hydrocarbon components in inclusions. This technique uses vacuum desorption to remove the natural gas and light hydrocarbons in the free state of sandstone. After the sample crushed, rapid analysis of natural gas and light hydrocarbons in the inclusions by mass spectrometry, and the formation of volatile organic compounds and inorganic matter in terms of quantity and composition with depth, according to geochemical parameters of natural gas and light hydrocarbons. It can identify oil and gas layers in geological history, detect oil and gas migration channels, and evaluate cap closure and trap integrity.

3.3 Sample preparation and experimental procedures
According to the research require, this paper focuses on the Jurassic exploration layer, and collects the reservoir oil system in the vertical direction to obtain the vertical oil saturation change trend to identify the oil and gas reservoirs and paleo-oil columns. A total of 540 core and cuttings samples from 11 wells, including PC2 well, MS1 well and M5 well, in the study area were selected for analysis. First, the sample is initially screened. The sample taken does not need to be too much, about 5-10 g, and the cleaned sand is dried in an oven about 60 °C. Next, the sample taken or the water-washed sample is ground in a mortar and then examined under a binocular microscope to ensure that the quartz grit is in a discrete state. Finally, the milled quartz grit is screened with a 20-80 mesh sieve, and then the sample is roughly weighed with a balance, about 2 to 2.4 g, depending on the sample. The quality of the sample is not much related to the strength of the QGF, so the initial weight of the sample is not a critical factor.

Experimental procedure: ① Add the weighed sample to a beaker, add 20 mL dichloromethane, seal the small beaker with tin foil, and ultrasound for 10 minutes in the ultrasonic wave to remove the contaminants adsorbed on the surface of the quartz sand, and then in the oven. ② The dried sample was added 40mL 10% hydrogen peroxide, sonicated in ultrasonic for 10 minutes, then allowed to stand for 40 minutes, and then ultrasound for 10 minutes to ensure sufficient reaction. ③ Add 40mL 3.6% hydrochloric acid Stir with a glass rod for 20 minutes, then rinse with distilled water, then dry in an oven. ④ Weigh the dried sample, in condition of the weight of the sample is over 0.3g, add 20mL re-distilled methylene chloride, then seal the small beaker with tin foil paper, ultrasonically in the ultrasonic for 10 minutes, QGF-E analysis of the extract, the processed sand is placed in the special sample QGF analysis was performed in the pan.

4. Experimental results and discussion
In this study, 11 key exploration wells in the southeast, central and northwest of the Mosuowan uplift were selected, and 540 core rock samples were collected. The quantitative fluorescence of the reservoir particles and the quantitative fluorescence analysis of the extract were analyzed due to sample selection and pollution. Factor impact, the effective data is 520. There were 203 fluid inclusion stratigraphy FIS analysis, of which 197 were valid data.

4.1 Quantitative fluorescence analysis experimental results
The hydrocarbon accumulation process is a process of increasing oil and gas saturation. The oil inclusions under the microscope prove the existence of micro-scale reservoirs, but the height of hydrocarbon columns in industrial-value reservoirs is on the order of several meters to several hundred meters. In this paper, the fluorescence intensity QGF-E of hydrocarbons bound hydrocarbon QGF and free hydrocarbons in particle extracts in the reservoir particles was measured by laser scanning analysis. The fluorescence intensity of hydrocarbons can reflect the abundance of oil inclusions. The change of the fluorescence intensity response generated on the depth profile to identify the paleo-oil layer and the paleo-oil interface. The big data analysis of QGF experimental and interpretation explains the basic principle of the oil layer is from the water layer to the oil layer, the overall QGF-E value shows an upwardly significant increase, the value changes 1-2 orders of magnitude, the QGF-E value of oil layer is greater than 20. Besides, it is necessary to have a QGF-E value higher than 50-100 in the interval. The ancient oil layer or the residual oil layer means that the QGF index is greater than 10, and the transport interval is only a high value of the local QGF-E and QGF index, and there is no tendency to become significantly larger. The fluorescence peaks of oil and paleo-oil samples are similar to the fluorescence spectra of crude oil, mainly distributed at 375-475 nm. Taking the QGF and QGF-E scanning data of 43 samples in the depth of 4270.3~5250.3m in the PC2 well of the Mosuowan uplift as an example, the absolute value of the fluorescence index is lower than 10. There is a continuous high value at the depth of 4400-4590m and 4600-4820m, ranging from 10.0 to 24.5, and the maximum value of 24.5 appears at 4591m. With the 4820m boundary, the fluorescence index of the lower particles is obviously reduced. Based on this, the fluorescence spectrum of the paleo-oil interface at 4820m.4400-4820m is inferred. It shows that the spectral characteristics of 375-475nm are more obvious, and it has the asymmetric distribution characteristics of moving to short wavelengths. It is a typical spectral characteristic of crude oil, reflecting the passage or accumulation of oil and gas. In addition, there are 6 data out of 43 samples with QGF-E values exceeding 50, which provides data support for further determination of ancient oil layers (Figure 1).

Combined with hydrocarbon fluid geochemical parameters and comparative rock pyrolysis data, the oil layer exhibits a high ratio of QGF-E and QGF, and the corresponding S1 value is also relatively high. The oil test result of the J1s11 well in PC2 well is oily water layer, the total hydrocarbon content is almost zero, the pyrolysis parameter S1 of the reservoir rock is between 0.00-4.10, S2 is zero, the chloroform asphalt “A” content is low, QGF- The E-intensity index is greater than 20 and gradually increases as the buried depth becomes shallower. The results show that there are 3m oil column in the 4270~4273m section, 23m oil column in the 4408~4431m section, 2m oil column in the 4490~4615m section, 6m oil column in the 4609~4615m section, and 4682~4686m well. There is a 4m oil column in the section and a 4m oil column in the 5128~5132m section.

4.2 The analysis of fluid inclusion stratigraphy

Fluid inclusion stratigraphic analysis data gives gaseous hydrocarbons C1-C5, liquid hydrocarbons C6-C13, water-soluble organics benzene, toluene, organic acids, etc. in the form of ion abundance. Non-hydrocarbon gas(CO2, H2S and other abundances) vary vertically, from which oil and gas layers in geological history can be identified, oil and gas migration pathways can be detected, and cap closure and trap integrity can be evaluated. The CH4 signal intensity of the oil layer is generally greater than 200,000. The CH4 and C2H6 intervals of the PC2 well are mainly located in the two layers of 4408-4431m and 4490-4615m. These two intervals also have the high value of QGF-E, which proves the two layers are the main oil layers. However, over 4600m depth, the values of CH4 and C2H6 are significantly reduced, and the numerical changes are important for the judgment of ancient oil layers(Figure 2).
4.3 Discussion

Through the rock pyrolysis, QGF and FIS scanning analysis of 11 exploration wells in the Mosuowan uplift, the QGF-E intensity is bounded by 20, and the oil column height is greater than this value. The oil and gas layers of these exploration wells are identified. The distribution of oil and gas intervals in the exploration well is out. Based on this, it is identified that the M23 well has a section of ancient oil column with a maximum height of 25 m. There are 6 ancient oil columns in PC2 well, among which 6 wells of PC2 have been identified, the maximum height is 20m, and the rest are less
than 20m. It is identified that there are 7 ancient oil columns in Mo21 well, with a maximum height of 40m; It is identified that there are 2 ancient oil columns in the core section of Mo5 well and Mo6 well, with a maximum height of 10 m; Mo24 well has 5 sections of ancient oil columns with a maximum height of 15 m; Moshen 1 well has 4 sections of ancient oil columns, the largest The height is 70m. There are two ancient oil columns in Mo22 well on the east side of the PC2 well, with a maximum height of 50m. The Mosuowan uplift is the southern section of the Fang2 well, and the maximum height is 10m. The Fang 3 well has a section of ancient oil column with a maximum height of 5m. The number of samples in the Dong2 well is not divided into ancient oil columns.

Comprehensive research shows that, in combination with structural analysis, most wells in the Mosuowan bulge paleo-oil reservoir exist in the present oil column, but the oil column height is generally small, most of which is less than 20m, indicating that the Mosuowan uplift does not form a broad-cover type. The oil and gas reservoirs are multi-layered lithologic reservoirs with a certain tectonic setting (ancient high point). Most wells do not have obvious ancient oil columns (the QGF index of the ancient oil column is greater than 10, and the measured QGF index is less than 10). Whether from gas or rock pyrolysis logging, or QGF and FIS analysis, we still can't get the exact value of the interval oil saturation, indicating that these methods still have limitations in dividing the oil layer. The high values of gas and rock pyrolysis logging, or the high values of CH\textsubscript{4} and C\textsubscript{2}H\textsubscript{6} for QGF-E and FIS, indicate better oil and gas display or hydrocarbon abundance, and the key to industrial production of oil in the hydrocarbon reservoir is The relative permeability of the oil phase. The height of the oil and gas column is small, and the buoyancy pressure is small, resulting in a low overall oil saturation. We believe that this small-scale reservoir is difficult to achieve large-scale reconstruction without strong structure, such as fracture due to the top seal and side seal.

5. Conclusion
(1) Most of the wells have the present oil column in the exploration layer of the Sangonghe Formation, but the height of the oil column is generally small, and most of the single layer is less than 20m, indicating that the Mosuowan uplift does not form a broad-cover reservoir. Sedimentary lithologic reservoirs with a certain tectonic setting (ancient high point) independent of each other.

(2) Most wells do not have obvious ancient oil columns (the QGF index of the ancient oil column is greater than 10, and the measured QGF index is less than 10); there is no large-scale long-distance adjustment from south to north and then migration to re-accumulate.

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