Geochemical Characteristics and Oil-Gas Source Identification of The SN31 Oil and Gas Reservoir in The Junggar Basin

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Abstract: Recently, with the improvement of exploration levels, there has been disputes about the geochemical characteristics and sources of oil and gas reservoirs in the SN31 well block of the Junggar Basin, and they need to be re-evaluated. By collecting crude oil and natural gas samples from key wells, testing, and analysing the components, stable carbon isotopes, and biomarkers of the samples using laboratory physical calibration, chromatography-mass spectrometry, and other methods, the physical and chemical characteristics, genetic types, and sources of oil and gas can be identified. The results show that the relatively low API value indicates a light to medium oil. The crude oil has a relatively high carbon isotope content, distributed between -29.4‰ to -28.7‰. The ratio of pristane (Pr) to phytane (Ph) indicates that the crude oil originates from humus-rich source rocks. The higher content of tricyclic terpenes and rearranged steranes indicates higher maturity. The content of C_{27}>C_{29}>C_{28} indicates that the crude oil is mixed with a certain proportion of higher plants. The natural gas content is high, and the drying coefficient is 0.86~0.94, which is indicted mainly wet gas. The non-hydrocarbon components are mainly N_2 and CO_2. The carbon isotope characteristics show that the methane carbon isotope distributes from -33.4‰ to -35.3‰ and the ethane carbon isotope distributes from -24.7‰ to -26.6‰. The comparison suggests that the crude oil and natural gas are mainly from the Lower Permian Wuerhe Formation. This study has some theoretical guidance for the future exploration and development of oil and gas in the Junggar Basin.

Keywords-Geochemical characteristics; Oil-gas Source; Highly mature oil-gas of humic type; SN31 oil and gas reservoir; Junggar Basin

1 Introduction

The SN31 well block has developed Cretaceous strata and the main oil and gas producing formation is the Qingshuihe Formation. Tectonically, it belongs to the Sanan Depression of the basin. The reservoir is a monoclinic structure tilted to the south, with a relatively gentle structure and a stratigraphic dip angle between 2° and 3°, and the development of fracture features is not obvious [1,2]. The reservoir is a reservoir with tectonic lithology characteristics, and the reservoir is controlled by the oil-water interface along the up-dip direction of the sand body tip extinction and the down-dip direction (Figure 1). 40.8km^2 of oil-bearing area, 2119×10^{4}t of petroleum geological reserves and 635.7×10^{4}t of recoverable reserves are in the Qingshuihe Formation of the SN31 well block.

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The stratigraphy of the Qingshuihe Formation in the SN31 well block is mainly lacustrine and braided river delta deposits, with gray muddy fine sandstone, sandy mudstone and mudstone in the upper middle part, gray fine sandstone, muddy fine sandstone and medium sandstone in the lower middle part, and brown mudstone in the bottom part [3-5]. The average porosity of the reservoir is 13.9%, the average permeability is 13.6 mD, the pore type of the reservoir is mainly intergranular pores and intragranular pores, and a small amount of microfractures, the reservoir is medium and low pore-permeability, the discharge pressure is low, the pore space is more developed, and the pore connectivity is good [6,7].

At present, a lot of research work has been carried out around the SN31 reservoir [8-11]. Due to the limited technology and data in the early stage of exploration, the comparative understanding of oil and gas geochemical characteristics and source needs to be re-understood and re-evaluated. The identification of oil and gas sources is an important link in oil and gas exploration [12,13]. Usually, parameters such as oil and gas geochemical characteristics and biomarker compounds are used for calibration [14,15]. Based on this, this study collected crude oil and natural gas samples from key wells, and analyzed the sample components, physical properties, carbon isotopes and biomarker compounds by using new laboratory calibration standards and chromatography-mass spectrometry techniques to identify the genetic types and source of hydrocarbon and provide theoretical guidance for future oil and gas exploration and development in the SN31 well block.

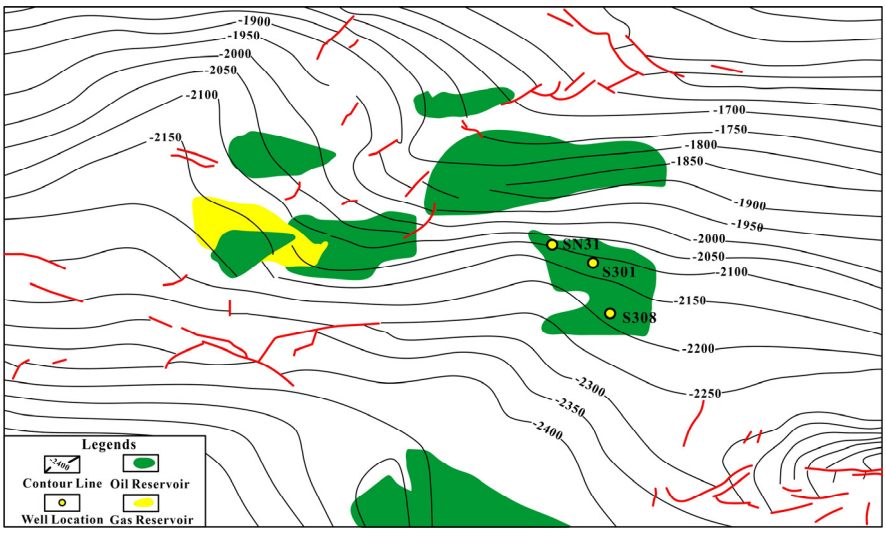

Figure 1. Location of SN31 oil-gas reservoir in central Junggar Basin

2 Data And Methods

2.1 Data Collection

The experiment collected 8 samples of crude oil and 7 samples of natural gas. The samples were analyzed and tested at the State Key Laboratory of Oil and Gas Resources and Exploration.

2.2 Data Test

The physical properties of crude oil test include density, viscosity, wax content. Among them, density is measured by crude oil and liquid petroleum products density laboratory determination method as the standard (GB/T 1884-2000); viscosity is measured by petroleum products kinematic viscosity determination method and dynamic viscometer algorithm as the standard (GB/T 265-83); wax content is measured by crude oil wax content determination as the standard (GB/T 26982-2022).

The natural gas component content test is calibrated by gas chromatography method for composition analysis of natural gas (GB/T 13610-202); the carbon isotope content test of crude oil and natural gas is calibrated by organic matter and carbonate carbon and oxygen isotope analysis method (SY/T 5238-2019).

3 Results

3.1 Physical Properties of Crude Oil

The API value of crude oil in the oil-bearing section of the Qingshuihe Formation in the SN31 well block ranges from 31.0 to 41.7, with an average value of 38.2, which is light-medium quality oil. The viscosity ranges from 3.6 mPa·s to 8.0 mPa·s, with an average value of 5.3 mPa·s, and the wax content ranges from 5.0% to 7.9%, with an average value of 6.7%. With the increase of the formation depth, the crude oil of the Qingshuihe Formation does not change much, the viscosity increases and the wax content shows a decreasing trend (Figure 2).

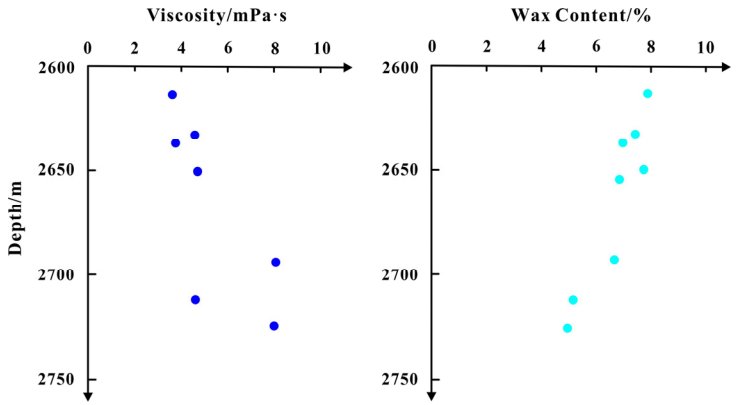

Figure 2. Characteristics of crude oil viscosity (left) and wax content (right) with formation depth in SN31 well block

3.2 Carbon Isotope and Biomarker Compound Characteristics of Crude Oil

The carbon isotope distribution of crude oil in the Qingshuihe Formation in the SN31 well block ranges from -29.4‰ to -28.7‰, with an average value of 29.1‰. The whole-hydrocarbon gas chromatogram of crude oil shows that the distribution of n-alkanes is basically complete, with most of the low carbon number alkanes, the main peak carbon position is more forward, the Pr/Ph value is greater than 1, but the Pr/Ph values are lower than those of the adjacent n-alkanes.

The distribution characteristics show that the crude oil of the Qingshuihe Formation in the SN31 well block has a high maturity. The distribution pattern of C_{27}, C_{28} and C_{29} rule steranes is "V" type (Figure 3).

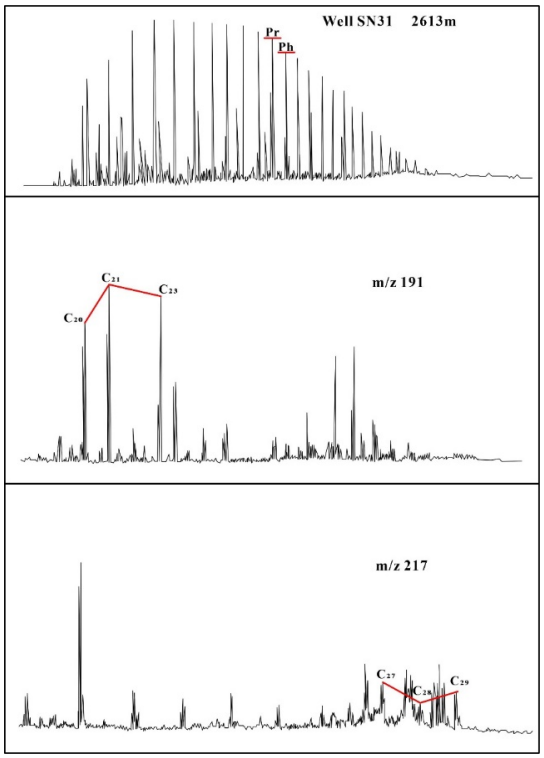

Figure 3. Mass spectra of crude oil in SN31 well block

3.3 Natural Gas Component Characteristics

The methane content in the natural gas of SN31 well block is 83.11%~91.61%, and the heavy hydrocarbon gas content is 6.0%~14.2%, with the drying coefficient of 0.86~0.94, which is mainly wet gas. The non-hydrocarbon components are mainly N_2 and CO_2, with contents ranging from 1.6% to 3.3% and 0.05% to 0.65%, respectively.

3.4 Carbon Isotope Signatures of Natural Gas

The natural gas carbon isotope characteristics in the SN31 well block are -33.4‰ to -35.3‰ for methane and -24.7‰ to -26.6‰ for ethane.

4 Discussion

The characteristics of changes in physical properties of crude oil reveal that the deep crude oil becomes heavier and more viscous, and the oil and gas should mainly originate from the lower source rocks. Based on the carbon isotope distribution characteristics of crude oil and natural

gas samples, it is found that the oil and gas in SN31 well block originates from hydrocarbon source rocks with high maturity and partial humic type. Moreover, the tricyclic terpene content of crude oil is high, and the distribution of C_{20}, C_{21} and C_{23} tricyclic terpenes is "Λ" type, and the distribution of C_{27}, C_{28} and C_{29} rule steranes is "V" type, and the content of C_{27}>C_{29}>C_{28} indicates that the oil source rocks are mixed with the content of C_{27}>C_{29}>C_{28} indicates that the oil source rocks are mixed with a certain proportion of higher plants. It is concluded that the oil and gas mainly originate from the hydrocarbon source rocks of the lower Permian Wuerhe Formation.

5 Conclusion

SN31 well block has huge oil and gas resources, and the oil and gas producing formation is mainly in the Qingshuihe Formation. The crude oil is low-density, medium-light crude oil, with low-viscosity and low-wax content, and shows a trend of increasing viscosity and decreasing wax content as the burial depth of the formation increases. The natural gas content is high in methane, mainly wet gas, and low in non-hydrocarbon gas components.

The distribution characteristics of carbon isotopes and biomarker compounds of crude oil and natural gas show that the oil and gas in the SN31 well block are mainly of high maturity and humic type, and the source of oil and gas is mainly the lower Permian source rock formation.

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