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Geochemical characteristics and origins of the oil in Tazhong, Tarim Basin

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In Tazhong, the nature and distribution of oil and gas is very complex, the reservoirs are of various types,and the source of oil and gas has been a very difficult problem. According to the whole oil $\delta^{13}C$ and monomer hydrocarbon $\delta^{13}C$ characteristics the oil in Tazhong area originates from the same source, mainly from the Cambrian – Ordovician. The comparison with molecular weight hydrocarbon C_9 ~ C_{18} fingerprints, once again proved that tower area oil is from a uniform oil source. The conventional biomarker compounds are used to distinguish between typical Cambrian - Ordovician oil sources, and the aromatization class misogamy alkalies detection prove that all the oil and gas have condensed from anaerobic, strong reducing environment, deposited under the action of photosynthetic green sulfur bacteria in Cambrian-Ordovician source rocks.

Key words: Carbon Tazhong, Carbon isotope, Geochemical characteristics, Oil source correlation

INTRODUCTION

The oil and gas resources in Tazhong area are very rich [1, 2, 3].This area is one of the key strata for oil and gas exploration.Currently, a series of breakthroughs were achieved in the Tazhong 4zone, Tazhong Ⅰ belt, Tazhong 10.Found from the reservoir [4, 5], not only the nature and distribution of oil and gas are very complex, but the oil and gas source problem has always been very hard to avoid. The main reason is that hydrocarbon source rocks involve carbonate rocks, which have always been a major problem of geochemical research field both at home and abroad [1,6,9], and hydrocarbon source rocks are very old, they involve upper Paleozoic hydrocarbon source rocks, maturity difference is big, complex tectonic evolution history and thermal evolution history had experienced several phases of oil and gas gathering and destruction, all of which increase the difficulty of the study of oil source correlation. In this paper, we study the ethnic division and oil source identification in Tazhong area through the geochemical characteristics of Ordovician crude oil.

SAMPLE COLLECTION AND EXPERIMENTAL METHODS

The samples were stored in 5ml glass bottles to prevent oil pollution, using bottle pads with tin foil. Samples were placed in a -6℃ freezer after collection. Light hydrocarbons (C_4-C_8) and saturated hydrocarbons were analyzed by gas chromatography using ms fine quartz wool column equipped with DB-1MS (60 m×0.20 mm×0.25μm) Agilent 6890GC chromatographic instrument injected directly with the helium carrier gas. In order to detect lighter hydrocarbon compounds, the initial temperature was set to 35℃for 5 min.The heating rate was 2℃/minup to 135℃.

Later C^{13}following ingredients were washed at a heating rate of 6 ℃/min up to 300 ℃.

AND DISCUSSION

Carbon isotope characteristics of crude oil

The results of carbon isotope analysis in Tazhong area of crude oil and condensate (Table1) show that the carbon isotopes are very light, generally less than32‰ (Fig.1), carbon isotopes in the Cambrian and lower Ordovician source of oil in Lunnan area are mainly distributed in the31.1～32.6‰, carbon isotopes of oil in the areas are relatively light and located in the south and north sides of Man JiaEr sag, which should have the same source.

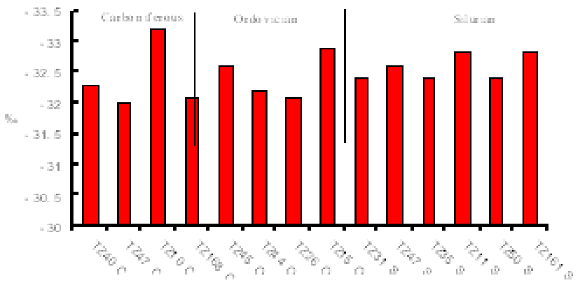

Fig.1. Carbon isotope of oil distribution in Tazhong area

In Tazhong area, consequently, the oil and various group carbon isotopic compositions are consistent with the Lunnan area.

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Geochemical characteristics of light hydrocarbon in crude oil

Light hydrocarbons are an important part of condensate and crude oil, which are from about 1/4 to 1/3 of the total amount of crude oil [5, 6], the biomarker compounds content in the crude oil were accounted for only 1% or less, in the overall characteristics of the crude oil the light hydrocarbon compounds are more representative than the biomarkers. In fact, the former were in higher amounts and the composition of light hydrocarbons was related to the characteristics of kerogen type and maturity.

Group Composition of C_4- C_7

Humic type organic matter derived from higher plants, compared with the sapropel type organic matter, were rich in benzene, toluene, methyl cyclopean and cyclopean compounds, while the latter was relatively rich in naphthenes [5]. Studies of light hydrocarbon group composition of C_4~ C_7in the area showed that chain alkanes content was mainly 52 ~79%,the content of aromatics was 3~ 11%.It is relatively rich in alkenes and lean aromatics, which is characteristic of oil and saprogenic source rocks of the typical source(Fig.2)

C7 group

Research showed that the heptane mainly came from algae and bacteria while methyl cyclohexane mainly transformed from higher plants, lignin and cellulose [7, 8],which are good examples of parameters for terrigenous parent material type; the lipid compound2-methyl cyclopentane mainly came from aquatic organisms,therefore,using the three kinds of composition as a triangular diagram of n-heptane,methyl cyclohexane and 2-methyl cyclopentane,the condensate can be distinguished between different sources of oil and crude oil. Wang Tingdong studied the light hydrocarbon compounds of the C_7 group from some condensate oils and crude oils in Sichuan and the Tarim Basin. They confirmed that these parameters can be well distinguished from different genetic types of condensate oil and crude oil. The n-heptane content is 47-65% and the methyl cyclohexane content is 23~39% in the composition of condensate and crude oil C_7 of light hydrocarbons. The analysis results are shown in the group composition diagram (Fig.3) which falls in type parent material area, therefore, we can judge that it was a sapropelic type rock source.

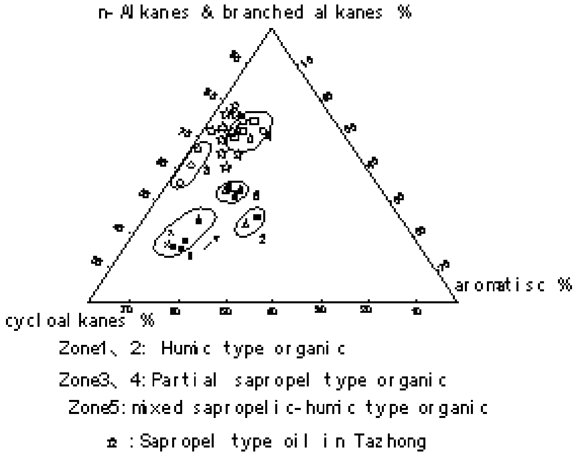

Fig.2. Triangle composed of light hydrocarbon of condensate oil and crude oil C_4-C_7 in Tazhong

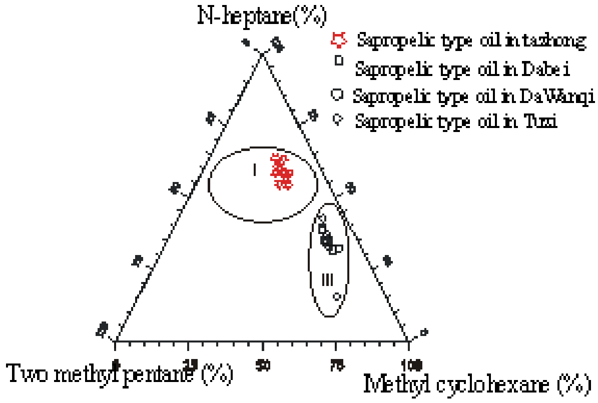

Fig. 3. Triangle composed of light hydrocarbon of condensate oil and crude oil C_7 in Tazhong.

The ratio of light hydrocarbon compounds Erdman identification

The method of light hydrocarbon fingerprint determination, proposed by Erdman in 1974, had obtained widespread application in the oil-oil correlation study [8, 9]. The analysis of Erdman data from the Tazhong area according to the parameter mapping showed good similarity in the crude oil area (Fig. 4),which indicated that they should belong to the same source. However, these crude oils differed poorly in comparison with Tazhong low uplift of the middle upper Ordovician argillaceous limestone and the further evidence showed that only the Cambrian and lower Ordovician source rocks provided the main contribution to the oil and gas currently found in theTazhong area.

Table 1. Carbon isotope composition of crude oil in Tazhong Area.

Well No.	Well depth, m	Hori-zon	Samples	Totality oil	Saturated hydrocarbon	Aromatic hydrocarbon	Non hydro-carbon	Asphal-tene
				$\delta^{13}C$/‰	$\delta^{13}C$/‰	$\delta^{13}C$/‰	$\delta^{13}C$/‰	$\delta^{13}C$/‰
tz40	4307.35-4343	C		-32.3	-32.5	-32.2		
tz47	4216.4-4335.3	C_{I-II}	oil	-32	-32.7	-32.3	-32.4	-31.7
tz10	4139-4150	C_{II}	oil	-33.22				
tz168	3799-3850	C_{III}	oil	-32.1	-33.5	-32.3		
tz45	6020-6150	O	oil	-32.6	-30.5			
tz44	4854-4877	O	oil	-32.2	-32	-32		
tz26	4300-4360	O	oil	-32.1	-31.7	-31.9		
tz15	5238-5247	O	oil	-31.7	-31.3	-31.6		
tz15	4656-4673	O	oil	-32.9	-33.1	-32.7		
tz31	4946-4951	S	oil	-32.4	-32	-32.3		
tz47	4978.5-4986	S	oil	-32.6	-32.9	-32.9	-32.4	-32.6
tz35	4946-4951	S	oil	-32.4	-32	-32.3		
tz11	4294-4434	S	oil	-32.8				
Tz50	4378-4385	S	oil	-32.4	-32.3	-32.1		
Tz161	4178-4181	S	oil	-32.8	-33	-33.8		

Table 2. Comparison of biomarker parameters from source rock of Cambrian and Ordovician.

Hydrocarbon source rock / Biomarker parameters	Source rocks of lower middle Cambrian-Lower Ordovician	Source rocks of middle upper Ordovician
Gammacerane/C_{31}hopane	High	Low
C_{28} Sterane	High	Low
C_{27}、C_{28}、C_{29} Sterane distribution	$C_{27}<C_{28}<C_{29}$ or $C_{27}>C_{28}<C_{29}$	$C_{27}>C_{28}<C_{29}$
Tricyclic terpanes/hopane	High	Low
Diasterane/regular steranes	Low	High
Long chain tricyclic terpaneC_{28}、C_{29}	High	Low
HopaneC_{31}/C_{30}	Low	High

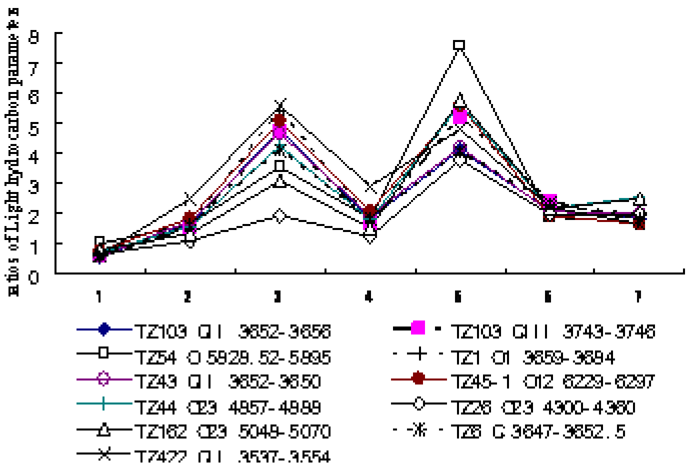

Fig. 4. Comparison chart on hydrocarbon parameters by Erdman of Crude oil and condensate light.

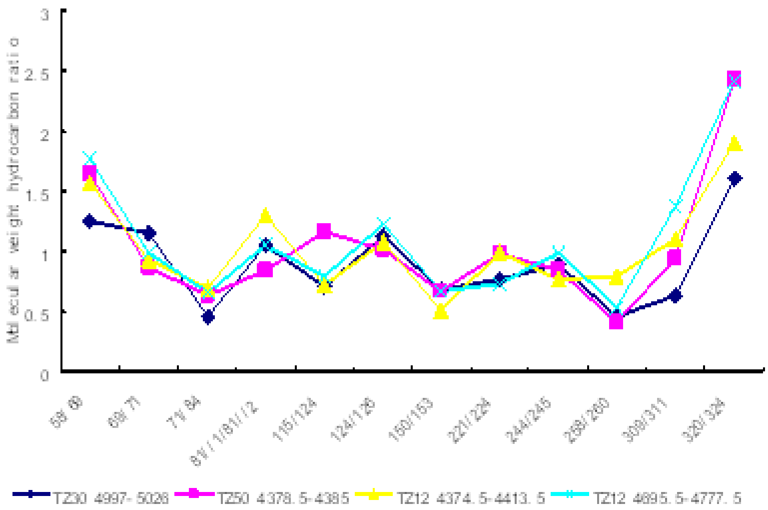

Fig. 5. Comparison of molecular weight hydrocarbon in crude oil.

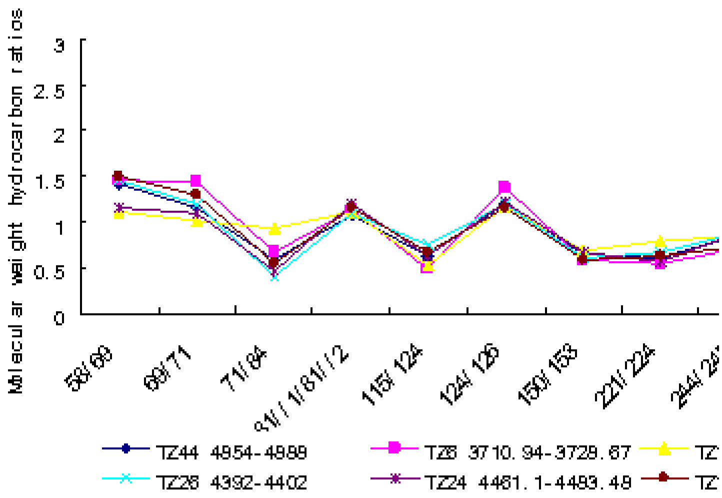

Fig. 6. Comparison of molecular weight hydrocarbon in Condensate oil.

Middle molecule weight hydrocarbon

Comparison of hydrocarbon molecular weight is mainly performed using compounds of molecular weight similar to (C_9~C_{18}) for isomeric alkane carbon number, some of the same general alkanes, chain alkanes with a methyl substituent and isoprenoid alkanes.The comparison results of the fingerprints of crude oil, condensate oil molecular weight hydrocarbons in Tazhong area shows that there was resemblance between the samples (Figs.5, 6), suggesting that these oils have the same source. From the results of molecular weight hydrocarbons we couldn't decide whether the crude oil was derived from the middle upper Ordovician source rocks, or from the Cambrian source rocks, but it gave us a very clear message that the oil or condensate found in Tazhong had only one main source

Biomarker characteristics of Sterane and terpane

According to the identification of the conventional biomarkers sterane and terpane, the oil and condensate oil in Tazhong Ordovician originated from the Cambrian and lower Ordovician source rocks, including TZ45,TZ44,TZ24 and TZ26 in upper Ordovician, the carboniferous oil of TZ24 also originated from the Cambrian and lower Ordovician source rocks.(Table2). In addition, carboniferous condensate of TZ1and TZ1- 6 wells in the east of Tazhong Low Uplift, part of the oil in Tazhong 16 wells area and portion of the oil or oil sands oil from TZ10, TZ11 were all derived from Cambrian. These oils were of consistent biomarkers of TC1 Cambrian oil and typical Cambrian hydrocarbon source rocks, which have the characteristics of high gammacerane and high C_{28} sterane (Fig.7).

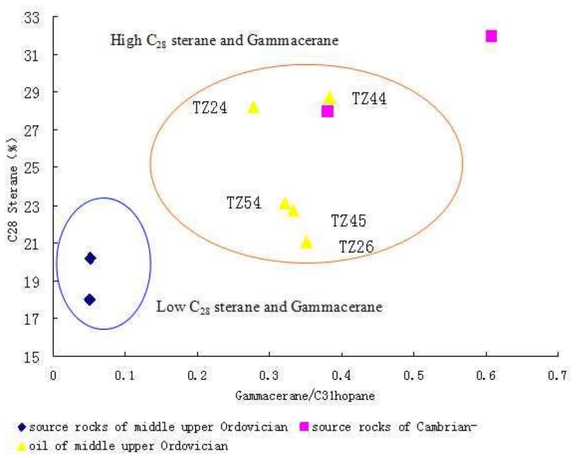

Fig. 7. Oil source contrastion of crude oil and condensate.

In addition, in a large number of reservoir bitumens characteristics of the typical Cambrian source of oil were detected (Table 2) and these reservoir bitumens have the characteristics of high content of gamma cerane and C_{28}sterane.

Isoprenoid hydrocarbon aromatization

Aromatization of isoprenoid hydrocarbons takes place in anaerobic, strong reducing environment by photosynthetic green sulfur bacteria, which is a sign of strong reductive water environment [10, 11, 12, 13]. In Tazhong area, whether the conventional biomarkers were determined to be source of Cambrian oil or were judged as similar oil source rocks from middle upper Ordovician, (Figs.8,9,10)we detected the aromatization isoprenoids to prove that these oils were formed from the hydrocarbon source rocks which deposited in the anaerobic and strong reducing environment.

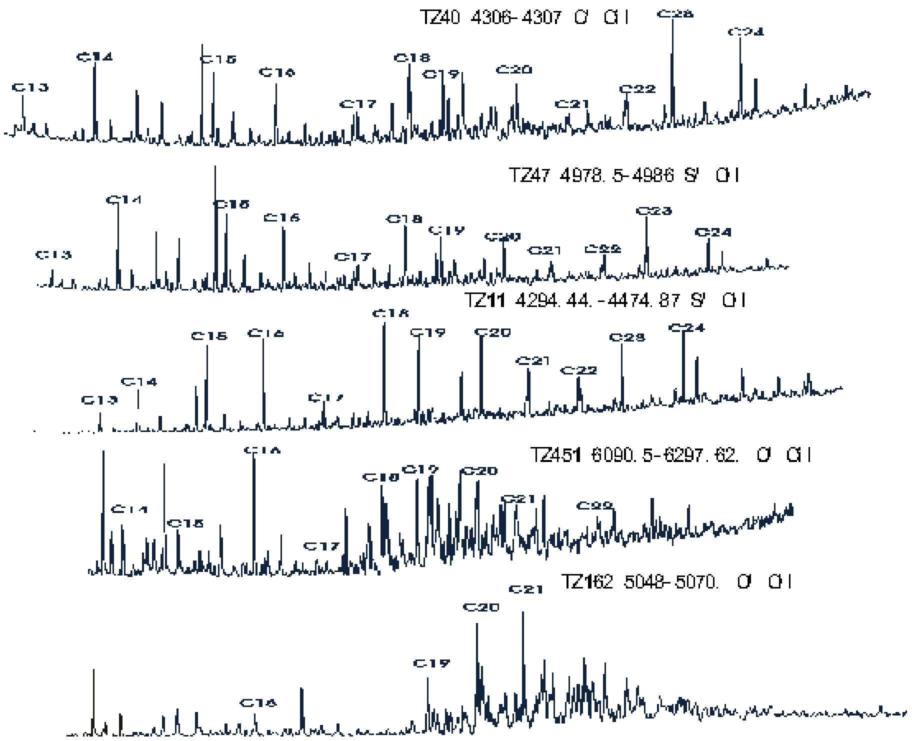

Fig. 8. The isoprenoid hydrocarbon mass chromatogram of TZ40, TZ47, TZ11, TZ451 and TZ162.

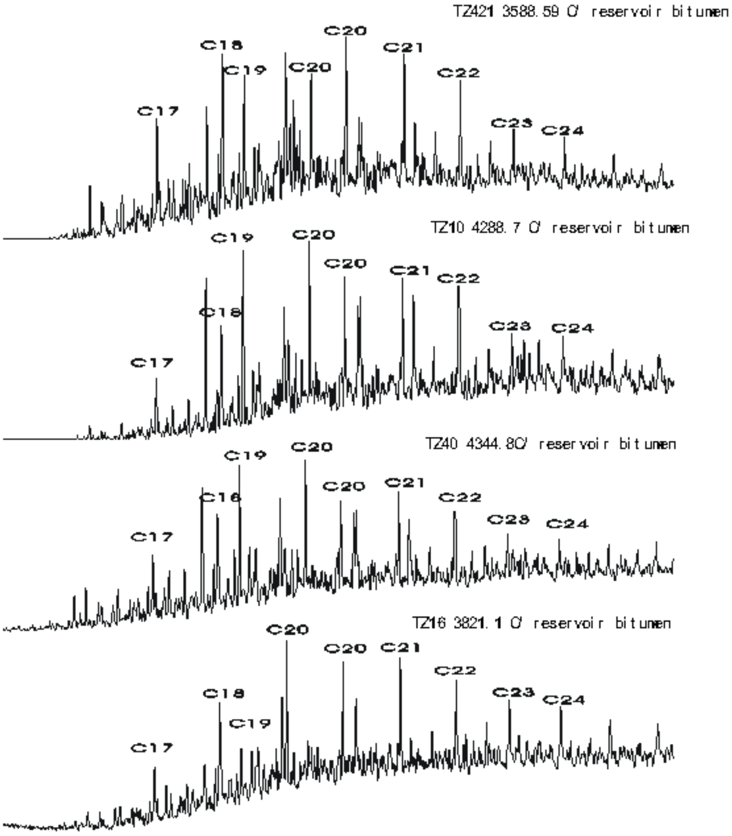

Fig. 9. The isoprenoid hydrocarbon mass chromatogram of TZ421, TZ10, TZ40 and TZ16.

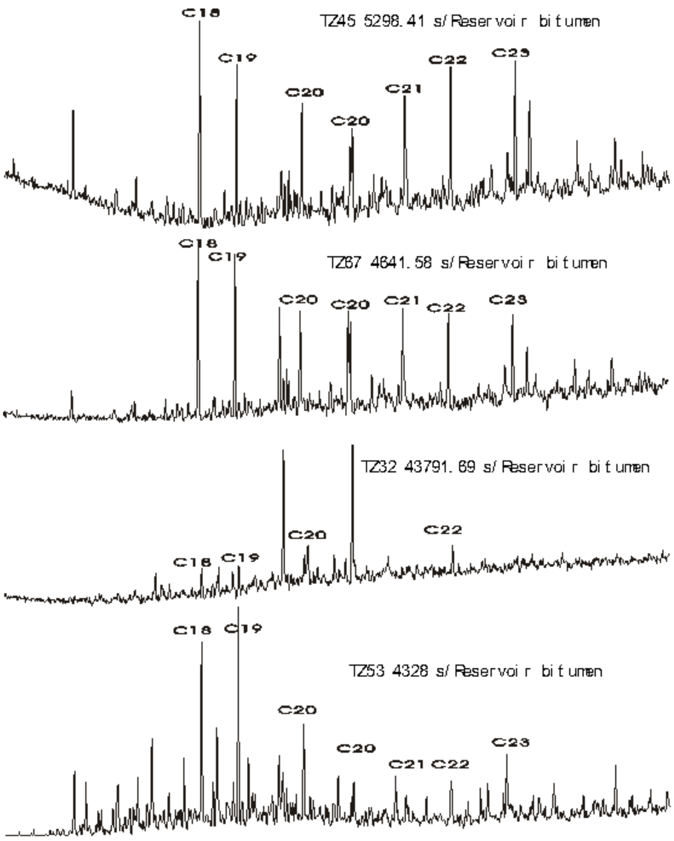

Fig. 10. The isoprenoid hydrocarbon mass chromatogram of TZ45, TZ67, TZ32 and TZ53.

CONCLUSION

The main sources of crude oil and condensate oil in Tazhong area are the Cambrian and lower Ordovician source rocks, with a small contribution of oil generated from middle and upper Ordovician source rocks. Carbon isotopes of crude oil and condensate, monomer hydrocarbon carbon isotopes and molecular weight hydrocarbon fingerprint distribution showed that they had the same source; light hydrocarbons proved that oil and condensate were not derived from middle upper Ordovician source rocks. Conventional biomarkers over theTazhong area proved that most of oil and condensate oil came from the Cambrian and lower Ordovician source rocks. Aromatization class isoamyl two olefin certify that oil and condensate were derived in anaerobic and strong reducing environment, a photosynthetic green sulfur bacteria playing a role in the deposition of Cambrian and Lower Ordovician source rocks.

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ГЕОХИМИЧНИ ХАРАКТЕРИСТИКИ И ПРОИЗХОД НА ПЕТРОЛА В ТАЖОНГ, БАСЕЙН ТАРИМ

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(Резюме)

В Тажонг е трудно да се определят природата и разположението на петрол-съдържащите естествени резервоари. С помощта на белязан въглерод $\delta^{13}C$ и белязани мономери на въглеводороди с $\delta^{13}C$ е установено, че петролът в района Тажонг е от източник от периода Камбрий-Ордовисиан. Чрез сравнение на молекулните тегла на въглеводороди с формула C_9 - C_{18} е доказано още веднъж, че петролът в Тажонг е от един източник. Конвенционалните биомаркерни съединения, с които се установява източника Камбрий-Ордовисиан и наличието на ароматизирани изотерпенови въглеводороди доказват, че целият нефт и газ се получават от анаеробна, силно редукционна среда и отлагане под действието на фотосинтезиращи зелени тиобактерии в скалите от периода Камбрий-Ордовисиан.