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Mechanism of Hydrocarbon Migration of Paleozoic Clastic Rocks in Western Section of the Tabei Uplift, Tarim Basin: YM34 Silurian Accumulations as a Case

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Abstract. The oil and gas resource of YM34 Silurian accumulations is abundant, with a great potential for exploration and development. However, there is less research on the hydrocarbon migration mechanism because of complex structure and few data in the YM34 Silurian accumulations. By using gas chromatography-mass spectrometry (GC/MS) technique, the group composition, and biomarkers, including N-alkanes, isoparaffin and steroid hopane from saturated hydrocarbon and methyl phenanthrene, alkyl dibenzothiophene (DBTs) and triaromatic steroid(TAS) from aromatic hydrocarbons, which from 108 samples in 20 representative wells of YM34 Silurian accumulations and its peripheral reservoirs, are systematically analyzed and studied. The results indicate that: (1) along direction of hydrocarbon migration, the MPR, F1, and F2 increase, but the MPI1 decreases, which is caused by the relative larger amount of phenanthrene in the samples; (2) during oil and gas migration, the geochromatography effect of triaromatic steroid will happen. Along the migration pathway, the value of C_{27}(20R)/C_{28}(20R) increases; (3) the hydrocarbon charging point of YM34 Silurian accumulations is in the western YM342 and YM343 wells, and oil and gas are charged from west to east, which has certain

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guiding significance for progressive evaluation and development geological modeling of YM34 Silurian accumulations.

Keywords: Silurian accumulations · Hydrocarbon migration · Gas chromatography-mass spectrometry (GC/MS) · Geochromatography · Hydrocarbon compound

1 Introduction

Hydrocarbon compounds in oil can be divided into two categories of saturated hydrocarbon and aromatic hydrocarbon, and their biomarkers contain large amounts of information including source materials, sedimentary environment, hydrocarbon migration, and so on. Compared with saturated hydrocarbons, the aromatic hydrocarbons have stronger resistance to biodegradation and wider application in maturity study; therefore, a lot of research work has been carried out [1–6]. Zha Ming et al. found that the geochromatography effect of N-alkanes would happen during oil and gas migration, such as relatively short chain and small molecular weight compounds are relatively easier to transport than long chain and large molecular weight and more concentrated along the migration direction [7]. The polarity of aromatic hydrocarbon in oil is stronger than that of saturated hydrocarbon, and the non-hydrocarbon compounds of large molecular weight, such as colloidal and asphaltic, are easily adsorbed by the mineral surface. Therefore, with the increase of transverse migration distance, the content of colloidal, asphaltic, and aromatic hydrocarbons in the oil decreases, resulting in the increase of saturate to aromatics ratio and total hydrocarbon. Also, the fractionation effect occurs during the vertical migration of oil and gas, resulting in the increase of saturated hydrocarbon content and ratio of saturate to aromatics from the bottom to top, and the distribution features of aromatic hydrocarbon, non-hydrocarbon, and asphaltene content having the opposite tendency [8]. The researches of polycyclic aromatic hydrocarbons, aromatic steroid terpane, and sulfur-containing aromatic compounds show that the values of MPR, F1, and F2 increase along the migration direction, and the ratios of 4-MDBT to 1-MDBT, 2,4-DMDBT to 1,4-DMDBT, and 4,6-DMDBT to 1,4-DMDBT of DBTs have a decreasing trend with the increase of migration distance, but the content of TAS increases gradually, which can be used as a molecular parameter to trace the way and direction of oil filling [9, 10].

2 Geological Background

YM32 buried hill reservoirs is located in the YM32 Paleozoic buried hill belt, the western segment of Lunnan low salient of Tabei uplift in Tarim basin and the north is adjacent to Kuqa depression (Fig. 1). According to the pay zone, the reservoirs can be divided into the YM34 Silurian reservoir and the YM32 Cambrian–Ordovician reservoir. After 12 years of hydrocarbon discovery in the Devonian Donghe sandstone, the

Paleozoic clastic rocks of Tabei uplift, in 2006, another breakthrough was made in Silurian Kepingtage Formation of YM34. In the early stage, the structure and geochemical characteristics of YM34 reservoir were studied, and the contrastive analysis shows that the oil and gas in the western segment of Lunnan low salient of Tabei uplift mainly come from the lacustrine mudstone of Triassic Huangshanjie Formation (T_3h) in the north Kuqa depression and some comes from the coal mudstones of Jurassic Yangxia Formation (J_1y) [11–13]. In recent years, with the progress of seismic processing and interpretation technology, the wells of YM342 and YM343 have been discovered with a lot of geological data obtained [14]. The analysis of physical property, components, and chromatogram-mass spectrometry of saturated hydrocarbon of the crude oil in YM34 Silurian reservoir suggests the oil and gas have obvious difference in the west and east of the reservoir, and the western oil, represented by wells YM342 and YM343, has the characteristics of lower density, lower viscosity, and lower ratio of saturate to aromatics, and the accumulation period of the west is also later than that of the east [15]. This paper focuses on YM34 Silurian reservoir, using hydrocarbon compounds of 108 samples from 20 wells of the surrounding reservoirs for GC/MS analysis, choosing $\Sigma nC_{21}-/\Sigma nC_{22}+$, pristane to phytane (Pr/Ph) and C_{27} trisnorhopane of saturated hydrocarbon, naphthalene and phenanthrene series and DBTs parameters of aromatic hydrocarbon to discuss the source rock and hydrocarbon migration characteristics.

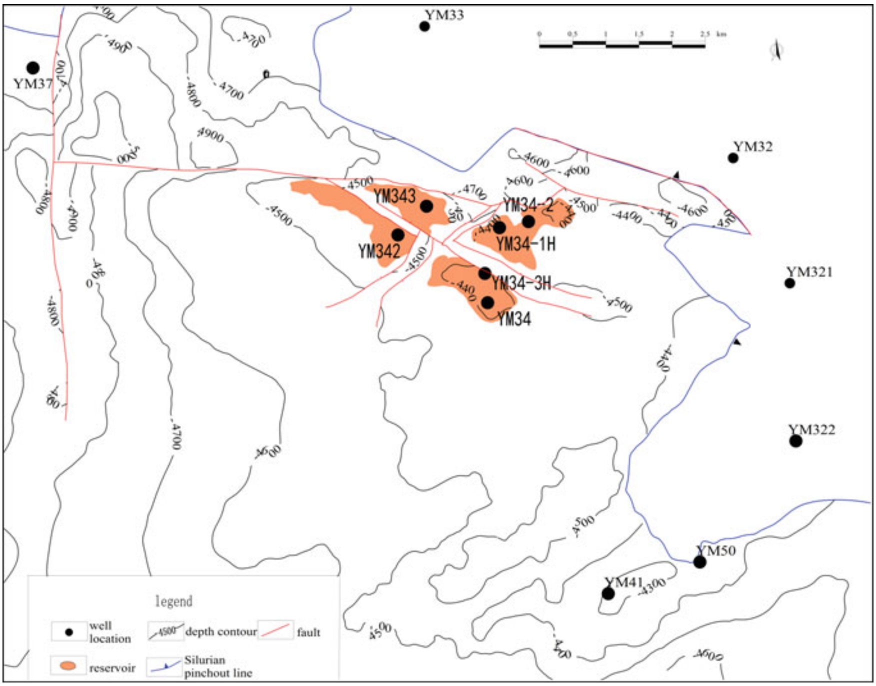


Fig. 1. Tectonic map of YM32 reservoirs

3 Characteristics of Oil Group Components

The characteristics of oil group components in YM32 buried hill reservoir are consistent (Table 1). The total hydrocarbon content is high, which is 61.76–85.67%, with an average of 76.1%, among which the values of Well YM34, YM342, YM343, and YM50 are above average, and Well YM34-1H and YM34-2 are less than average, which is close to the minimum value area. The saturated hydrocarbon content is between 53.2 and 71.14%, aromatic hydrocarbon content is between 8.56 and 19.93%, and the ratio of saturate to aromatics is from 3.1 to 7.86. The ratio of saturate to aromatics of Well YM342 and YM343 is slightly greater than 3, which is in the low-value distribution area.

Table 1. Characteristics of group components of crude oil in YM32 buride hilled reservoirs

Well name	Stratum	Saturated hydrocarbon (%)	Aromatic hydrocarbon (%)	Total hydrocarbon (%)	Non-hydrocarbon and asphaltenes (%)	Ratio of saturate to aromatics
YM34	S_1k	70.36	15.31	85.67	11.08	4.6
YM34	S_1k	65.95	16.26	82.21	13.81	4.06
YM34-3H	S_1k	57.58	11.45	69.03	28.96	5.03
YM34-1H	S_1k	60.06	12.34	72.4	24.3	4.87
YM34-2	S_1k	55.89	12.87	68.87	30.15	4.35
YM342	S_1k	57.72	18.23	75.95	19.37	3.17
YM343	S_1k	61.65	19.93	81.58	16.72	3.1
YM35	S_1k	64.01	15.98	79.99	20.01	4.01
YM37	S_1k	53.2	8.56	61.76	38.24	6.21
YM41	S_1k	58.91	16.34	75.25	24.26	3.61
YM50	S_1k	64.3	18.53	82.88	10.63	3.47
YM32	∈	57.3	18.39	75.69	21.62	3.12
YM321	∈	60.93	17.49	78.42	21.57	3.48
YM322	O	71.14	9.06	80.2	19.13	7.86
YM33	∈	57.48	14.17	71.65	13.62	4.06

4 Characteristics of Saturated Hydrocarbons

4.1 Normal Alkanes

The normal alkanes of oil in YM32 buried hill reservoir have a unimodal characteristic with carbon number distribution from nC_{10} to nC_{36} and main carbon number from nC_{14} to nC_{32}, carbon advantage index (CPI) value is slightly larger than 1, odd–even advantage is not obvious, and the oil belongs to the mature crude oil (Table 2). Geological chromatographic effect of n-alkanes will occur during the oil and gas migration, such as relatively short chain and small molecular weight compounds are relatively easier to transport than long chain and large molecular weight and more concentrated along the migration direction, and the ratios of $\Sigma nC_{21}-$ to $\Sigma nC_{22}+$ and $nC_{21}+ nC_{22}$ to $nC_{28}+ nC_{29}$ will also increase [7–16]. The ratios of $\Sigma nC_{21}-$ to $\Sigma nC_{22}+$ and $nC_{21}+ nC_{22}$ to $nC_{28}+ nC_{29}$ of YM32 buried hill reservoir, respectively, are from 0.48 to 4.29 and 1.62 to 3.61, and the values of Well YM342 and YM343 in the west of YM34 Silurian reservoir, respectively, are from 0.48 to 0.55 and 1.62 to 2.25, which are both in the low-value zone. The two ratios above of Well YM342 and YM34-1H in east of YM34 Silurian reservoir are apparently greater than that of the west, which infers that the oil and gas are likely to be charged from west to east in YM34 reservoir (Table 2).

4.2 Isoprenoid Alkane

The ratio of Pr/Ph is commonly used as biomarkers to study the input source rock types and differences of sedimentary environment in geochemistry. The high ratio of Pr/Ph represents pristane dominance, which indicates that the source rock is mainly from oxidized environment. The low ratio of Pr/Ph represents phytane advantage, which indicates that the source rock is mainly from reducing environment [17–19]. The Pr/Ph value of oil in YM32 buried hill reservoirs is from 0.99 to 2.23, which indicates the source rock may come from weakly reducing to weakly oxidized environment. The Pr/Ph values of Well YM342 and YM343 are around 1.0, which are in the extremely low area of YM32 buried hill reservoir, indicating weakly reducing lacustrine environment (Fig. 2, Table 2). The values of Well YM34, YM34-2 and Well YM32, YM33, respectively, are greater than 1.6 and around 2.0, gradually increasing from the west to the east, which indicate that the environment of source rock has a tendency to change to oxidized environment. The Pr/nC_{17} and Ph/nC_{18} values of oil in YM32 buried hill reservoirs, respectively, range from 0.16 to 0.63 and 0.08 to 0.16, and the Pr/nC_{17} value is greater than that of Ph/nC_{18}, which indicates that the oil has the characteristics of continental facies. The Pr/nC_{17} and Ph/nC_{18} values of Well YM342 and YM343 are greater than that of adjacent wells with a linear relationship, and this may have a connection with the higher maturity of the crude oil (Fig. 3).

The study shows that the ratio of Pr/Ph of lacustrine mudstone in Triassic Huangshanjie Formation ranges from 1.10 to 2.10, and the average values of Pr/Ph, $Pr/nC_{17,}$ and $Ph/nC_{18,}$ respectively, are 1.80, 0.44, and 0.29, indicating weak reduction environment. The ratio of Pr/Ph of coal-measure mudstone in Jurassic Yangxia Formation ranges greatly from 1.12 to 5.12, generally greater than 2.50, and the average values of Pr/Ph, $Pr/nC_{17,}$ and $Ph/nC_{18,}$ respectively, are 2.98, 0.85, and 0.31, which apparently higher than that of lacustrine mudstone, indicating weakly oxidized environment [20, 21]. That shows the environment of source rocks of Well YM342 and YM343 in the west of YM34 Silurian reservoir is similar to the sedimentary environment of Triassic Huangshanjie Formation, and the environment of source rocks of Well YM34 in the east of YM34 Silurian reservoir is similar to the sedimentary environment of Jurassic Yangxia Formation.

Table 2. Geochemical parameter of saturated hydrocarbon of crude oil in YM32 buried hill reservoirs

Well name	Stratum	Pr/Ph	Pr/nC_{17}	Ph/nC_{18}	Ts/(Ts + Tm)	20S	αββ	$\Sigma nC_{21}-/\Sigma nC_{22}+$	NC_{22}/NC_{29}	CPI	OEP
YM34	S1k	1.99	0.23	0.11	0.553	0.44	0.34	1.49	1.85	1.09	1.02
YM34-3H	S1k	1.65	0.19	0.11	–	–	–	1.11	2.31	1.08	1.1
YM34-1H	S1k	1.39	0.26	0.15	0.55	0.46	0.42	1.88	1.84	1.16	1.2
YM34-2	S1k	1.72	0.21	0.13	–	–	–	4.29	3.21	1.14	1.23
YM342	S1k	0.99	0.23	0.12	–	–	–	0.55	1.95	1.12	1.01
YM342	S1k	1.01	0.21	0.12	–	–	–	–	–	1.09	1.01
YM342	S1k	1.2	0.27	0.13	0.895	0.38	0.49	0.55	1.62	1.13	1.08
YM343	S1k	1.03	0.43	0.16	0.894	0.38	0.49	0.5	2.25	1.09	1.02
YM343	S1k	1.05	0.24	0.13	0.88	0.41	0.5	0.52	2.03	1.14	1.03
YM343	S1k	1.16	0.24	0.12	0.868	0.41	0.48	0.48	1.79	1.12	1.02
YM37	S1k	2.23	0.16	0.08	0.68	0.48	0.39	1.67	2.29	1.1	1.03
YM35	S1k	2	0.18	0.09	0.571	0.47	0.4	2.23	2.8	1.09	1.01
YM41	S1k	1.38	0.16	0.11	–	–	–	0.98	1.71	1.06	1.02
YM50	S1k	1.73	0.63	0.14	0.874	0.41	0.5	0.74	2.66	1.07	1.00
YM32	∈	2	0.18	0.08	0.577	0.49	0.44	2.33	2.23	1.18	1.37
YM33	∈	1.93	0.22	0.11	0.588	0.48	0.41	1.8	3.61	1.09	1.03

Notes

-: untested; 20S: C_{29}20S/(20S+20R), αββ:C_{29}αββ/(αββ+ααα); NC_{22}/NC_{29}: (nC_{21}+ nC_{22})/(nC_{28}+ nC_{29}), the same with Fig. 6

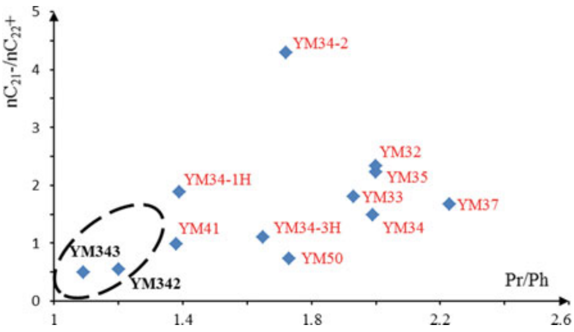


Fig. 2. Cross-plot of Pr/Ph versus $\Sigma nC_{21}-/\Sigma nC_{22}+$ of crude oil in YM32 buried hill reservoirs

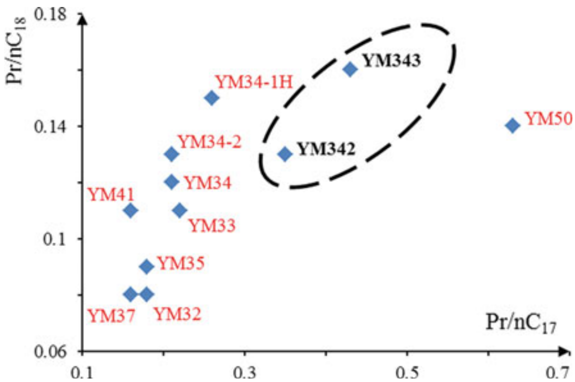


Fig. 3. Cross-plot of Pr/nC_{17} versus Ph/nC_{18} of crude oils in YM32 buried hill reservoirs

4.3 Steroid Terpenoid Series Compounds

Hopane is one of the most important compounds in pentacyclic triterpenoids, and the representative hopanes are C_{27} trisnorhopane Ts and Tm. The relative content of Tm generally decreases with the increase of the oil maturity and transform to Ts, which will increase the ratio of Ts/(Ts + Tm), the greater of the ratio of Ts/(Ts + Tm), the closer to the reservoir filling point, so the ratio is one of the important parameters to characterize the maturity of crude oils [22]. The analysis of existing GC/MS data of oils in YM32 buried hill reservoirs shows that the ratio of Ts/(Ts + Tm) ranges from 0.55 to 0.895 with mean value of 0.721. The ratio of Well YM342 and YM343 in the west of YM34 Silurian reservoir is greater than 0.89, in the maximum distribution area, where are the two filling points of the YM34 Silurian reservoir (Table 2). The ratios of Well YM34 and YM34-1H in the east of the reservoir range from 0.53 to 0.55, far below the mean value, which infer that the oil and gas of YM34 Silurian reservoir are charged from the west to the east.

The main peak of tricyclic terpane series of Well YM342 and YM343 in the west of YM34 Silurian reservoir is the C_{21} compound, and the abundance of C_{19}, C_{20}, C_{21} increases in turn, the abundance of C_{24} tetracyclic terpane is low, the content of Ts is far higher than that of Tm, the content of rearranged hopane is low, the abundance of gammacerane G, rearranged sterane, and regular sterane is high, presenting a "V" shape, content of C_{27}, C_{29}, C_{28} decreases gradually, showing C_{27} sterane advantage; all of these indicate that the provenance of hydrocarbon source rock has lower aquatic organisms input [23] (Fig. 4). The main peak of tricyclic terpane series of Well YM34 and so on in the east of YM34 Silurian reservoir is also the C_{21} compound, but the abundance of C_{19}, C20, and C_{21} is irregular, the abundance of C_{24} tetracyclic terpane is very low, the content of T_S is higher than that of Tm, the abundance of gammacerane G and rearranged sterane is medium and that of regular sterane is high, presenting a "V" shape, content of C_{29}, C_{27}, C_{28} decreases gradually, showing C_{29} sterane advantage, and the provenance of hydrocarbon source rock has higher plant input (Fig. 5).

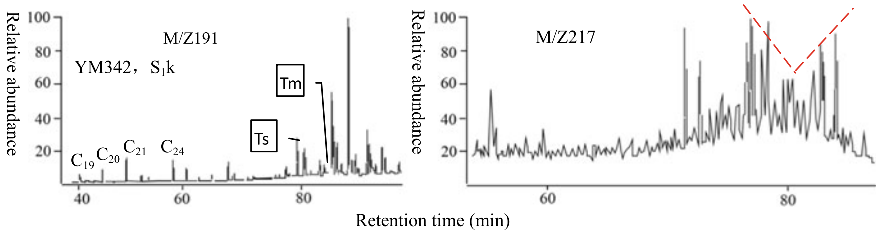


Fig. 4. Characteristics of steranes and terpanes in well YM342

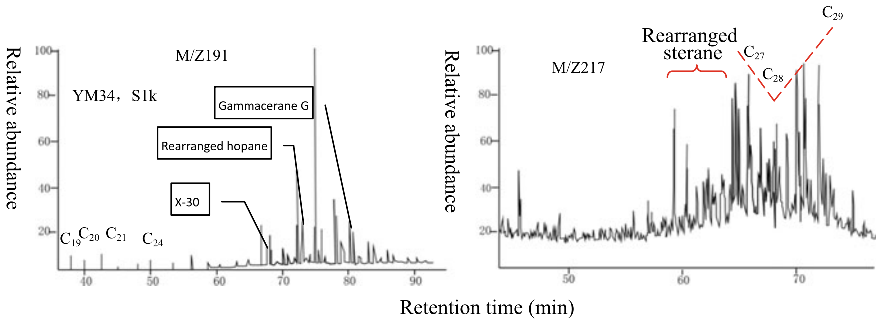


Fig. 5. Characteristics of steranes and terpanes in well YM34

The C_{29}20S/(20S+20R) and $C_{29}\alpha\beta\beta/(\alpha\beta\beta+\alpha\alpha\alpha)$ ratios of the C_{29} steroid are commonly used as the most important indicators to determine the maturity and oil source comparison, and indicate the direction of oil and gas migration [24]. Statistical analysis showed that, with the increase of the value of maturity parameters, such as Ts/(Ts + Tm) and so on, C_{29}20S/(20S+20R) and $C_{29}\alpha\beta\beta/(\alpha\beta\beta+\alpha\alpha\alpha)$ ratios increased too, showing a positive correlation. The analysis of correlation between the maturity of crude oil and C_{29} steroid of YM32 buried hill reservoir showed that the $C_{29}\alpha\beta\beta/(\alpha\beta\beta+\alpha\alpha\alpha)$ ratios of high maturity oil in Well YM342, YM343, and YM50 are in the high value area of the upper right corner of the figure, and the C_{29}20S/(20S+20R) ratios are in the relatively low-value area of the lower right corner, appearing an abnormal situation (Fig. 6).

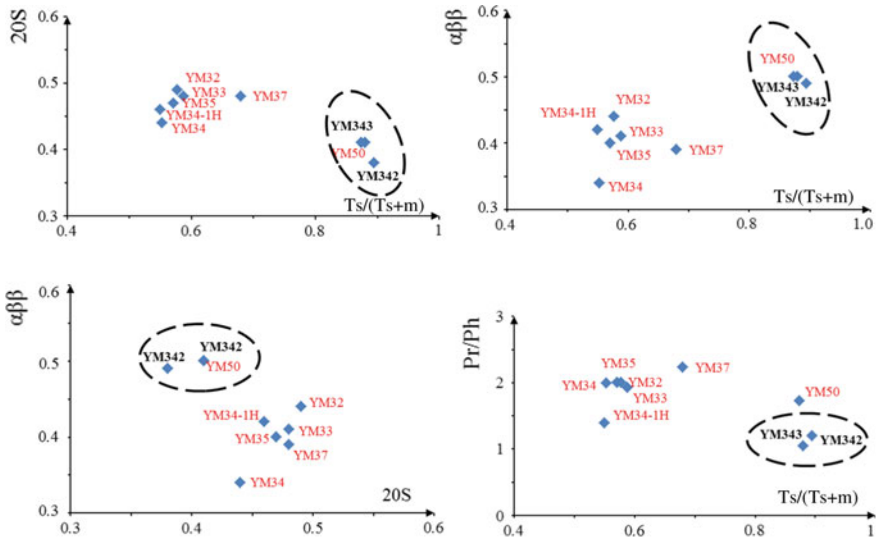
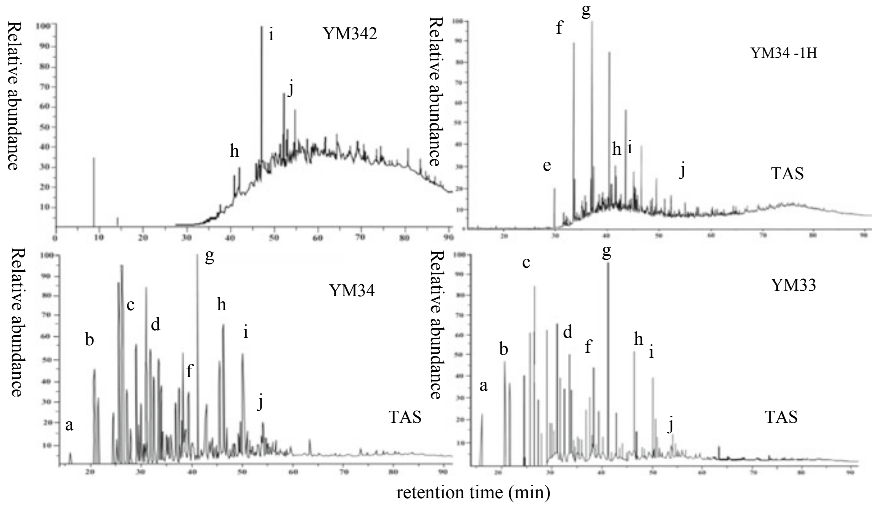


Fig. 6. Relation between $C_{29}\alpha\beta\beta/(\alpha\beta\beta+\alpha\alpha\alpha)$, C_{29}20S/(20S+20R), Pr/Ph, and Ts/(Ts + Tm) in YM32 buried hill reservoirs

5 Characteristics of Aromatic Hydrocarbons

5.1 General Characteristics of Aromatic Hydrocarbons Distribution

There are generally three main peak groups in the GC/MS graph of the aromatic compounds; the first are the naphthalene and alkyl naphthalene main peak groups, the second are the phenanthrene and alkyl phenanthrene, and the third are the aromatic steroid, terpenoid, and other polycyclic aromatic hydrocarbons, mainly tetracyclic or pentacyclic compounds. The general characteristic is unimodal peak in the total ion chromatography (TIC) of the aromatic hydrocarbon fraction of YM32 buried hill reservoirs, and according to the characteristics of the main peak groups, there are three types: The first type, such as Well YM342, YM343, and YM50, is well developed with the second and third main peaks without the naphthalene and alkyl naphthalene. The second type, Well YM34-1H and so on, is well developed with trimethyl naphthalene and tetramethyl naphthalene, the second and third main peak groups. The third type, such as Well YM34, YM33, and YM32, is well developed with the three main peak groups (Fig. 7).



a:N;b:MN;c:DMN;d:TMN;e:1,2,5-TMN;f:TeMN;g:P;h:MP;i:DMP;j:TMP.

Fig. 7. Mass chromatogram of aromatic compounds of YM32 buried hill reservoirs (TIC)

5.2 Characteristics of Naphthalene Series

The naphthalene series are dicyclic aromatic hydrocarbons and widely distributed in sediments and crude oil, mainly coming from terrestrial higher plants, and closely related to sedimentary environment and organic matter type. The main ones that can be detected in YM32 buried hill reservoir are naphthalene (N), methyl naphthalene (MN), dimethyl naphthalene (DMN), trimethyl naphthalene (TMN), tetramethyl naphthalene (TeMN), and pentamethyl naphthalene (PMN), with DMN and TMN of the highest and *N* of the lowest abundance (Fig. 8). Among the samples of YM32 buried hill reservoir, the naphthalene series of Well YM342 and YM343 are missing, which indicate that the terrestrial higher plants in the source rocks are few.

5.3 Characteristics of Phenanthrene Series

The phenanthrene series are tricyclic aromatic hydrocarbons. The main ones that can be detected in YM32 buried hill reservoir are phenanthrene (P), methyl phenanthrene (MP), dimethyl naphthalene (DMP), trimethyl naphthalene (TMP), and four MP isomers, 1-MP, 2-MP, 3-MP, and 9-MP (Fig. 8). Because the polarity of 1-MP and 9-MP is stronger than that of 2-MP and 3-MP, 1-MP and 9-MP are very easy to be adsorbed by rocks during migration; therefore, the values of methyl phenanthrene ratio (MPR), F1[=(3-MP+2-MP)/(1-MP+2-MP+3-MP+9-MP)], F2[=2-MP/(1-MP+2-MP+3-MP+9-MP) and MPI1[=1.5×(2-MP+3-MP)/(P+9-MP+1-MP)] increase along the migration direction [13–25]. The analysis of oil samples from YM32 buried hill reservoir shows

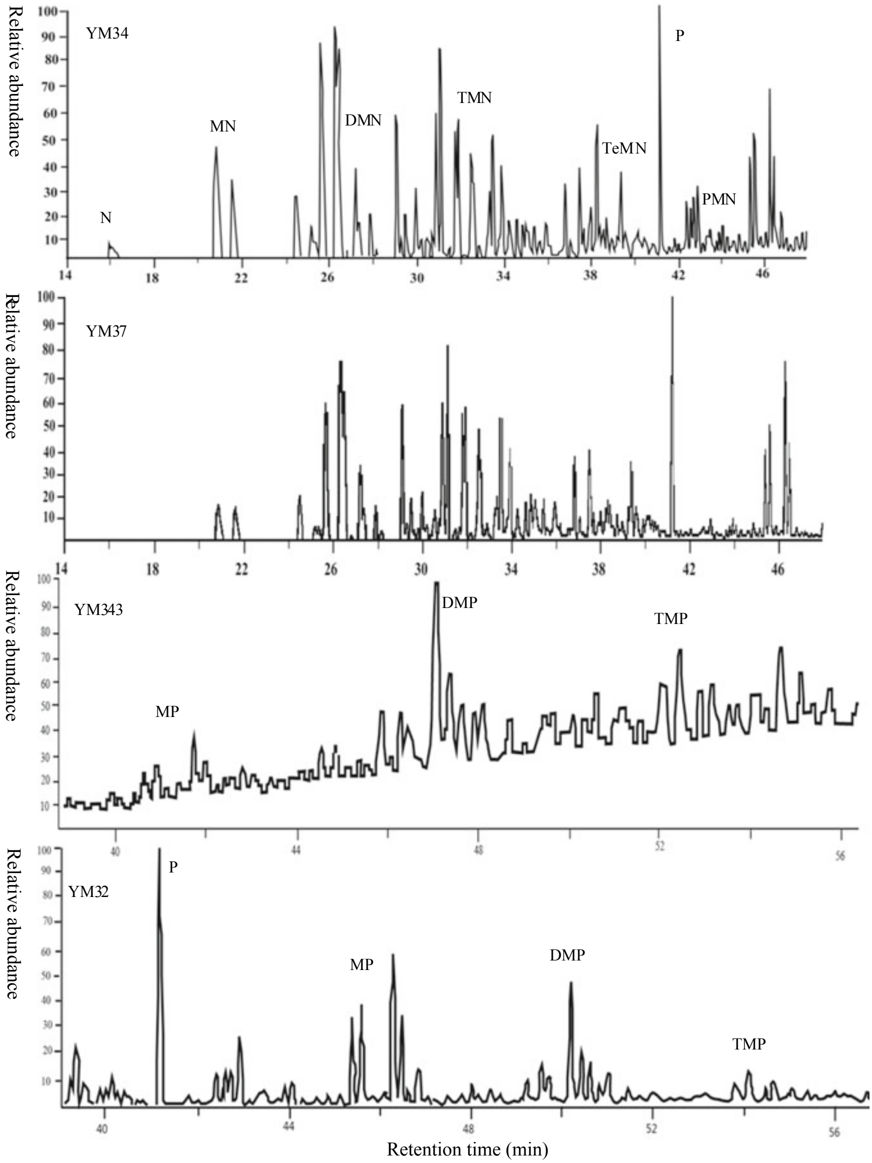


Fig. 8. GC/MS of aromatic compounds of YM32 buried hill reservoir (part of TIC)

that the values of MPR, F1, and F2 increase from the west to the east of YM34 Silurian reservoir, but that of MPI1 decreases, because of the low phenanthrene abundance of Well YM342, YM343, and so on of the west one, and the higher phenanthrene abundance of Well YM34-1H and so on of the east one (Fig. 8, Table 3).

Table 3. Parameter of aromatic compounds of oil samples in YM32 buried hill reservoirs

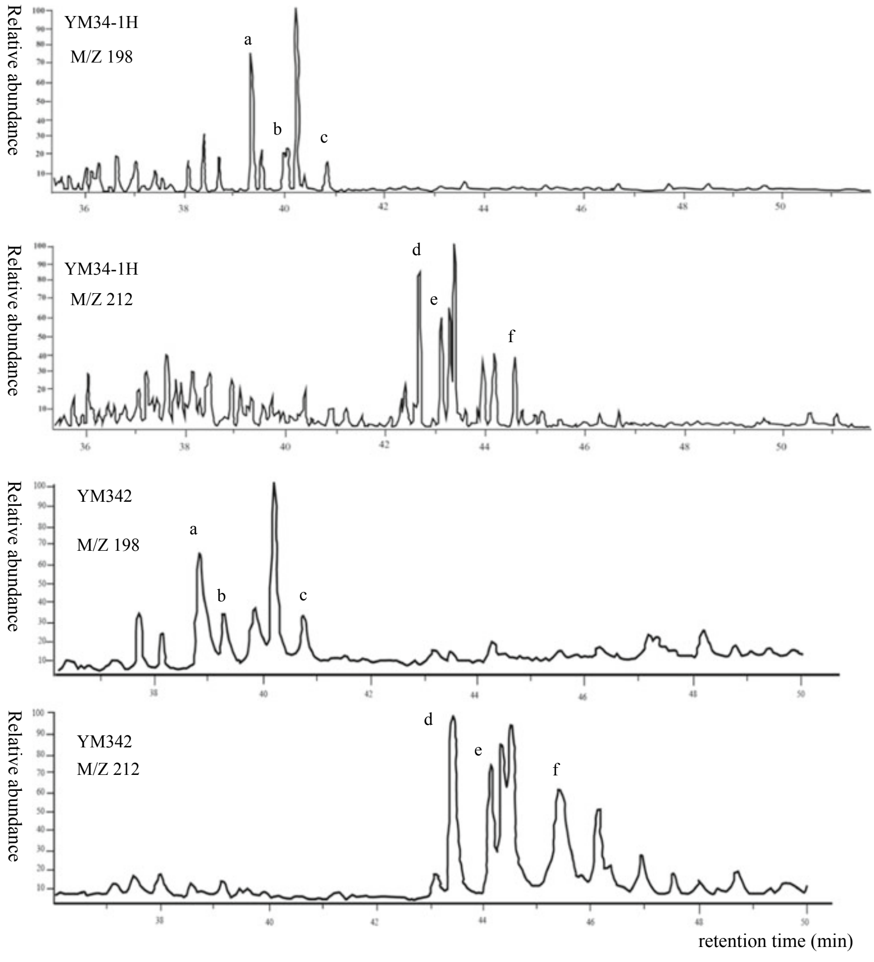
Well (sample number)	Stratum	MPR	F1	F2	MPI1	4-/1-MDBT	2,4-/1,4-DMDBT	4,6-/1,4-DMDBT	$TASC_{27}(20R)/C_{28}(20R)$
YM34	S	1.27	0.477	0.246	0.64	2.31	–	–	0.645
YM34-1H	S	–	0.395	0.207	0.61	3.88	1.18	1.51	0.594
YM34C	S	1.34	0.484	0.273	–	–	–	–	0.633
YM342(9)	S	0.92–1.12, ave:1.023	0.39–0.43, ave:0.41	0.19–0.22, ave:0.21	0.95–1.07, ave:1.00	4.1–5.88, ave:5.00	1.14–1.74, ave:1.46	1.98–2.93, ave:2.45	0.47–0.62, ave:0.55
YM343(4)	S	0.89–1.01, ave:0.94	0.38–0.41, ave:0.39	0.18–0.2, ave:0.19	0.88–1.03, ave:0.93	4.19–5.25, ave:4.9	1.25–1.77, ave:1.45	2.16–3.31, ave:2.58	0.47–0.52, ave:0.49
YM50(15)	S	0.75–1.23, ave:1.00	0.319–0.44, ave:0.39	0.16–0.24, ave:0.2	0.87–1.04, ave:0.96	3.1–5.86, ave:4.5	0.89–1.55, ave:1.2	1.81–2.52, ave:2.37	0.45–0.58, ave:0.53
YM35	S	1.08	0.42	0.224	0.53	5.51	–	–	0.562
YM37	S	1.16	0.44	0.234	1.15	5.84	–	–	0.651
YM39	S	0.58	0.28	0.196	0.3	1.98	–	–	0.343
YM39	O2y	1.62	0.59	0.296	0.44	–	–	–	–
YM32	K	0.87	0.364	0.185	0.44	6.18	–	–	–
YM32	∈	1.3	0.465	0.246	0.55	7.61	–	–	0.664
YM33	∈	1.22	0.458	0.242	0.55	7.39	–	–	0.673
YM33	∈	1.25	0.449	0.239	0.73	–	–	–	0.605
YM33-H1	∈	1.26	0.465	0.260	0.79	6.49	1.61	2.7	0.543
YM33-H4	∈	1.28	0.489	0.304	0.67	4.3	0.55	1.21	0.5
YM321	∈	1.31	0.463	0.244	0.54	7.61	–	–	0.689
YM321-H4	∈	1.26	0.5	0.255	0.77	5.99	1.54	2.67	0.651
YM322	∈	1.26	0.459	0.256	0.96	4.18	1.36	2.32	0.571

Notes

- means untested; ave means average value

5.4 Characteristics of Alkyl Dibenzothiophene Series

The DBTs are sulfur aromatic compounds. The analysis and detection of crude oil and rock swabbing samples of YM32 buried hill reservoir find that the MDBTs have three isomers: the 1-MDBT, 2,3-MDBT, and 4-MDBT, and the DMDBTs have three main isomers: 1,4- DMDBT, 2,4- DMDBT, and 4,6-DMDBT (Fig. 9). Because of the thermal stability difference, the MDBTs parameters, 4-MDBT/1-MDBT, 2,4-DMDBT/1,4-DMDBT, and 4,6-DMDBT/1,4-DMDBT decrease with the increase of migration distance and have a positive correlation with the maturity parameters, such as Ts/(Ts + Tm), so they can be used to trace the filling direction and migration path of oil and gas. The analysis show that the three above-mentioned MDBTs parameters of Well



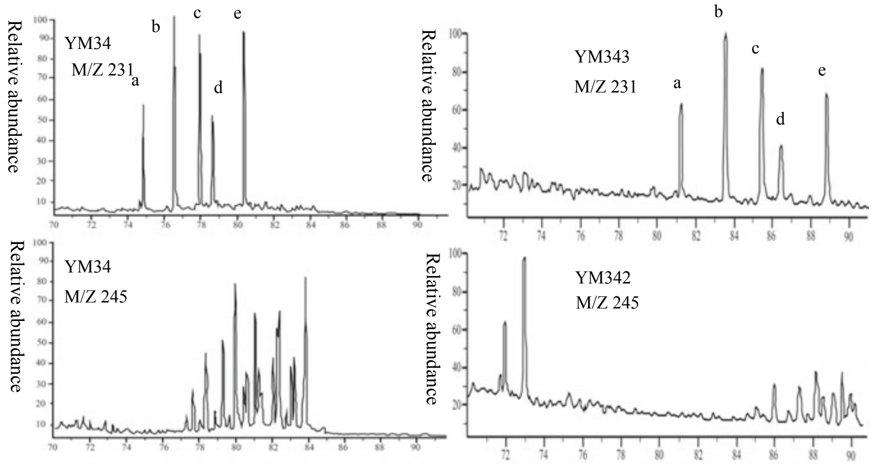
a: 4-MDBT;b: 2,3-MDBT;c: 1-MDBT;d: 4,6-DMDBT;e: 2,4-DMDBT;f: 1,4-DMDBT

Fig. 9. GC/MS of aromatic hydrocarbon fraction of YM32 buried hill reservoirs

YM34 in the east of YM34 Silurian reservoir are obviously smaller than that of Well YM342 and YM343 in the west of the reservoir, which infers that the migration path of oil and gas in YM34 Silurian reservoir is from the west to the east (Table 3).

5.5 Characteristics of Triaromatic Sterane (TAS)

In the GC/MS, the triaromatic sterane of YM32 buried hill reservoir can be two kinds of low carbon number (C_{19}–C_{22}) and high carbon number (C_{26}–C_{30}). The triaromatic sterane of high carbon number has R and S configurations, and the abundance of the three compounds, C_{26}20R +C_{27}20S, C_{28}20S, and C_{28}20R, is much higher than that of C_{26}20S and C_{27}20R (Fig. 10). The average value of TASC_{27}(20R)/C_{28}(20R) of samples from Well YM342 and YM343 in the west of YM34 Silurian reservoir is from 0.49 to 0.55, obviously smaller than that of Well YM34, YM34-1H, and YM34C in the east of the reservoir, from 0.594 to 0.645 (Table 3), which indicate that the geochromatography effect makes the value of TASC_{27}(20R)/C_{28}(20R) increase along the oil and gas migration path.



a: C_{26}20S;b: C_{26}20R, C_{27}20S;c: C_{28}20S;d: C_{27}20R;e: C_{28}20R;

Fig. 10. Mass chromatogram of triaromatic sterane of YM32 buried hill reservoir

6 Conclusion

The geochromatography effect will occur during oil and gas migration, especially in hydrocarbon compounds. The ratios of $\Sigma nC_{21}-/\Sigma nC_{22}+$ and (nC_{21}+ nC_{22}/nC_{28}+ nC_{29}) of n-alkanes in saturated hydrocarbons from samples of YM34 Silurian reservoir show that the ratios of the east and west of the reservoir are obviously different, and the value of the west is obviously smaller than that of the east. The ratio of Ts/(Ts + Tm) of C_{27} trisnorhopane shows that the value of the west is obviously greater than that of the east, indicating the maturity of the crude oil in the west is higher than that of the east and the west is closer to the oil filling point. The analysis of the saturated hydrocarbons reveals that the oil and gas may charge from the west to the east in YM34 Silurian reservoir. The values of MPR, F1, F2, and C_{27}(20R)/C_{28}(20R) of TAS in aromatic hydrocarbons of oil samples increase from the west to the east in YM34 Silurian reservoir, and the ratios of 4-MDBT/1-MDBT, 2,4-DMDBT/1,4-DMDBT, and 4,6-DMDBT/1,4-DMDBT of DBTs decrease from the west to the east, indicating that the hydrocarbon migration from the west to the east is obvious. From the above, the analysis of the hydrocarbon compounds indicates that the oil and gas charge from the west to the east in YM34 Silurian reservoir.

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Author Biography

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