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Geochemical Characteristics and Their Geological Significance of the Sterane in the Crude oil of Chang 2 Oil Group in Yanchang Formation in Xifeng area, Ordos Basin

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Abstract

Xifeng area is a key oil and gas exploration and development area in the Ordos Basin. The Chang 2 oil group of Yanchang Formation is an important replacement oil-bearing horizon in this area. The sterane compounds in the saturated hydrocarbons of crude oil contain abundant geochemical information and can reflect the source of parent materials and the maturity of crude oil, so they are important information carriers for oil source correlation(Huang et al.,1991; Duan,et al., 2001). In this paper, the crude oil samples were systematically collected from the reservoirs of Chang 2 oil group in 10 production wells in Xifeng area and the group compounds of crude oil were separated. The separated saturated hydrocarbon components were tested by chromatography-mass spectrometry (GC-MS) and the sterane compounds were identified and analyzed. The geochemical characteristics of the sterane in the saturated hydrocarbons of crude oil and their geological significance could provide a scientific basis for the oil source correlation of Chang 2 oil group at late stage.

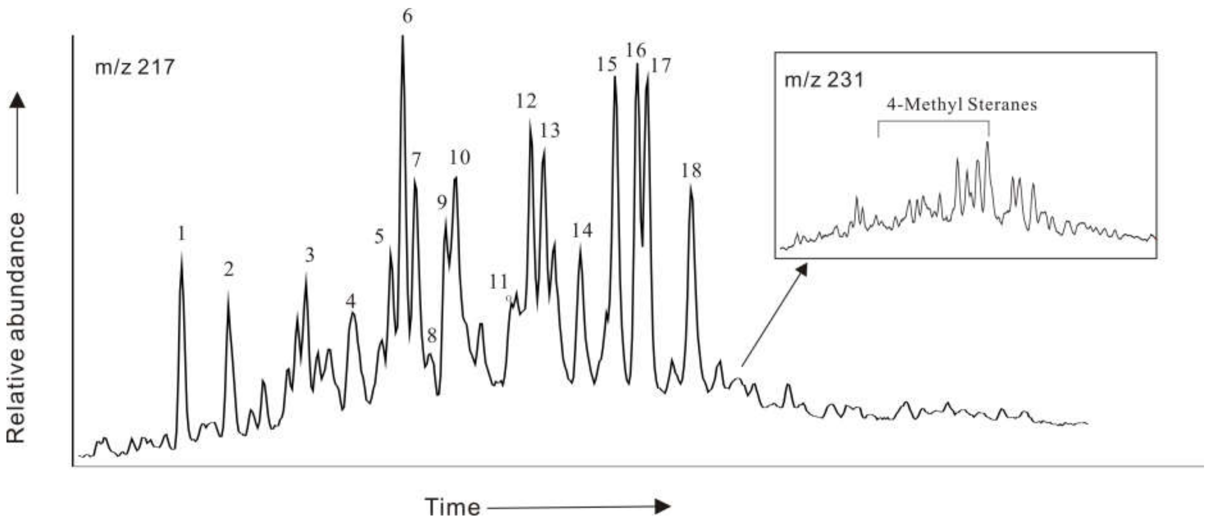

Fig. 1 Representative chromatograms of steranes, diasteranes, 4-Methyl Steranes of the crude oil of Chang 2 in Xifeng Area
Note: 1, dia-C27 20S; 2, dia-C27 20R; 3, dia-C28 20S; 4, dia-C28 20R; 5, C27 ααα20R; 6, dia-C29 20S; 7, C27 αββ20S; 8, C27 αββ20R; 9, C27 ααα20S; 10, dia-C29 20R; 11, C28 ααα20R; 12, C28 αββ20S; 13, C28 αββ20R; 14, C28 ααα20S; 15, C29 ααα20R; 16, C29 αββ20S; 17, C29 αββ20R; 18, C29 ααα20S.

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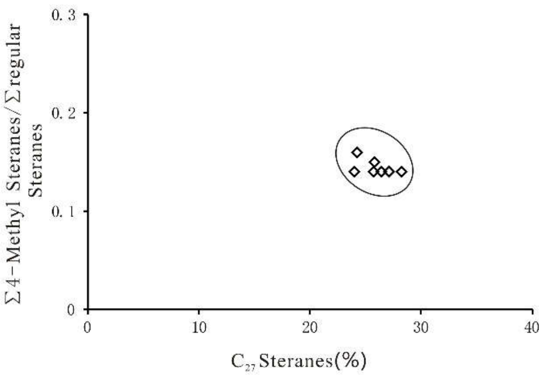

Fig.2 Cross plots of C_{27} Steranes vs. ∑4- Methyl Steranes/∑regular Steranes ratios of the crude oil samples of Chang 2 in Xifeng Area

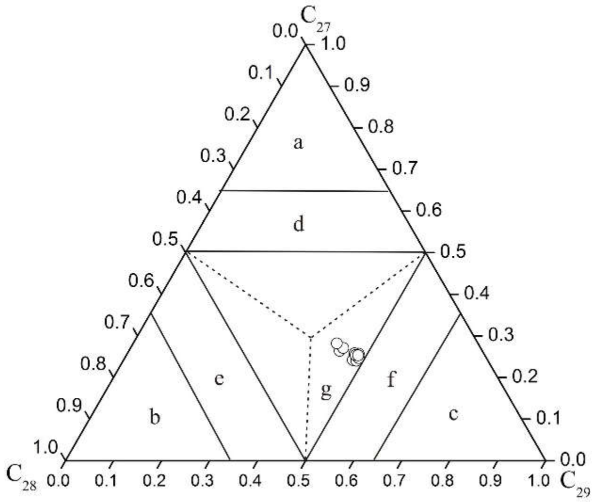

Fig. 3 Distribution triangular chart of different carbon number regular Steranes of crude oil samples of Chang 2 in Xifeng Area

Note: a-plankton; b-alga; c-terrestrial plant; d-dominated by phytoplankton; e-dominated by alga; f-dominated by terrestrial plant; g-mixed source

The distribution characteristics of the sterane compounds in the saturated hydrocarbons in the crude oil samples of Chang 2 oil group were shown in Fig.1. The content of each compound was shown in Table 1. The correlation diagram between C_{27} regular sterane and 4-methyl sterane /regular sterane was drawn. According to the distribution of the plotted sample points, the source of kerogen could be roughly judged (Zhang et al., 2017). As shown in Fig.2, the sterane in the crude oil samples of Chang 2 oil group was distributed in a narrow range, indicating the crude oil of Chang 2 oil group had similar kerogen. C_{27} regular sterane wasderived from aquatic algae plants, while C_{29} regular sterane was derived from terrestrial higher plants (Philp et al., 1991 ; Duan et al., 2001). As shown in Table 1, the relative content of the C_{27} regular sterane, C_{28} regular sterane and C_{29} regular sterane in the crude oil samples of Chang 2 oil group ranged between 24.0~28.2%, 26.1~29.7% and 42.4~48.7%, with an average value of 25.7%, 27.6% and 46.7%. Therefore, the C_{29} regular sterane in the crude oil samples of Chang 2 oil group had the highest content, followed by C_{28} regular sterane and C_{29} regular sterane. Their parent materials had mixed sources, which were aquatic organisms and terrestrial higher plants (Fig.3), between which, higher plants accounted for an important proportion (Duan et al., 2006).

Previous studies had suggested that 4-methyl sterane originated from dinoflagellates (Robinson et al.,1984). In this paper, abundant 4-methyl sterane was tested in the crude oil samples of Chang 2 oil group (Fig.1). The ratio between 4-methyl sterane /regular sterane ranged between 0.14～0.16, with an average of 0.144, reflecting dinoflagellates contributed to the formation of the crude oil of Chang 2 Formation in the study area.

Sterane could also be used to study the maturity of crude oil. It was generally believed that C_{29} sterane 20S/(20S+20R) and ββ/(αα+ββ) were both less than 0.2 at immature stage, 0.2~0.4 at low maturity stage and more than 0.4 at mature stage (Huang et al., 1991). C_{29} sterane 20S/(20S+20R) and ββ/(αα+ββ) was 0.49~0.54 and 0.53~0.59, respectively, with an average of 0.52 and 0.57 (Table 1). The values were all greater than 0.4, indicating the crude oil of Chang 2 oil group was at mature stage (Fig.4). In addition, C_{29} diasteranes 20S/20S+20R）.could also indicate the maturity of crude oil (Li et al., 1999; Zhang et al., 2000). The C_{29} diasteranes 20S/（20S+20R）was 0.45~0.62 in the crude oil of Chang 2 oil group, with an average of 0.52. The ratio basically reached an equilibrium value, indicating the crude oil of Chang 2 oil group was mature crude oil.

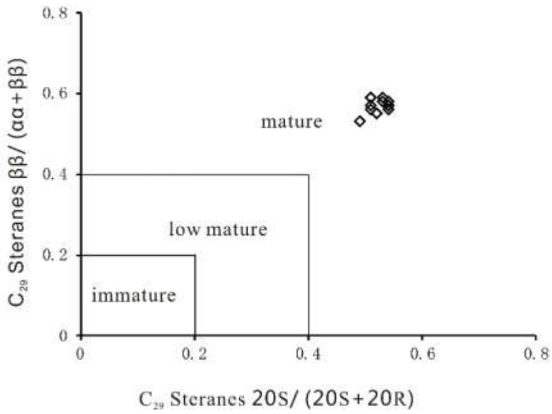

Fig. 4 Cross plots of C_{29} Steranes 20S/ (20S+20R) vs. C_{29} Steranes ββ/ (αα+ββ) of the crude oil samples of Chang 2 in Xifeng Area

Table 1 Comparative data of steranes in crude oils of Chang 2 in Xifeng Area

Sample NO.	Reservoir	Regular sterane abundance(%)			A	B	C	D	E
		C_{27}	C_{28}	C_{29}					
NT1	Chang 2	24.2	28.1	47.7	0.18	0.16	0.51	0.59	0.50
NT2	Chang 2	26.4	29.7	43.9	0.22	0.14	0.52	0.55	0.50
NT3	Chang 2	27.1	28.6	44.3	0.19	0.14	0.49	0.53	0.45
NT4	Chang 2	28.2	29.4	42.4	0.26	0.14	0.54	0.56	0.52
NT5	Chang 2	25.7	26.1	48.2	0.23	0.14	0.53	0.58	0.56
NT6	Chang 2	25.8	26.9	47.3	0.24	0.15	0.51	0.56	0.51
NT7	Chang 2	24.0	27.4	48.6	0.23	0.14	0.54	0.57	0.62
NT8	Chang 2	24.7	26.6	48.7	0.26	0.14	0.53	0.59	0.53
NT9	Chang 2	25.4	26.8	47.8	0.23	0.14	0.51	0.57	0.50
NT10	Chang 2	25.3	26.4	48.3	0.24	0.15	0.54	0.58	0.50

Note: A-∑diasteranes/∑regular Steranes; B-∑4-Methyl Steranes/∑regular Steranes; C-C29 Steranes 20S/(20S+20R); D-C29 Steranes ββ/ (αα+ββ); E-C29 diasteranes 20S/(20S+20R).

Keywords: Crude oil; Sterane geochemistry; Parent material sources; crude oil maturity; Chang 2 oil group; Xifeng area;

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