ABNORMAL GEOCHEMICAL PHENOMENON IN THE OVER-MATURE WUFENG-LONGMAXI SHALE FROM JIAOSHIBA AREA, SICHUAN BASIN, CHINA

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Introduction

Wufeng-Longmaxi Formation in Jiaoshiba area is a very attractive target for shale gas exploration in China. Its organic matter type is sapropelic (type I), which has strong hydrocarbon generation potential. An integrated approach involving organic matter analysis, Soxhlet extraction, laser Raman and thermodynamic modelling was used to investigate the abundance and maturation of the organic matter in Wufeng-Longmaxi source rocks. The results show that the TOC ranges from 1.07 to 4.47% and the organic matter is over-mature. The bitumen reflectance calculated from laser Raman is 2.49~3.02%, while the vitrinite reflectance (Ro) calculated from thermodynamic modelling is 2.67~2.86%. Price (1993) pointed that C_{15+} hydrocarbons begin thermal cracking at Ro values of about 0.9%, and C_{2+} hydrocarbons are mostly destroyed by Ro values of 2.0%. However, in Wufeng-Longmaxi source rocks, hydrocarbons including n-alkanes with carbon numbers up to C_{30}, terpenoids and steranes have been observed from the gas chromatography–mass spectrometry. In this paper, the abnormal phenomenon will be reported and its origin will be discussed.

Abnormal geochemical phenomenon

In this study, 12 core samples from Wufeng-Longmaxi Formation are researched and representative distributions of hydrocarbons are displayed in Figure 1. Apparently, n-alkanes present a bimodal distribution, which is inconsistent with the sapropelic organic matter. Terpane is characterized by higher tricyclene content than pentacyclic triterpene. As one of the most efficient biomarkers, the C_{29}-sterane isomerization ratios are used most often to evaluate the organic matter maturity. The C_{29}-sterane-20S/(20S+20R) ratio rises from 0 to ~0.5 (0.52-0.55=equilibrium) with increasing maturity while the C_{29}-sterane-ββ/(αα+ββ) ratio rises from 0 to ~0.7 (0.67-0.7=equilibrium) (Seifert and Moldowan, 1986). However, the C_{29}-sterane-20S/(20S+20R) ratios of over-mature Wufeng-Longmaxi source rocks range from 0.33 to 0.43 and the C_{29}-sterane-ββ/(αα+ββ) ratios vary between 0.39 and 0.64, showing a maturity reversal. Additionally, aromatic fractions have abnormal high contents of fluoranthene and pyrene, reaching 14.90%, 7.70% respectively.

Origins of the abnormal phenomenon

Gao et al. (2015) reported that overpressure developed in the Wufeng-Longmaxi Formation in Jiaoshiba area during the hydrocarbon generation, with the maximum overpressure coefficient reaching 2.18. The overpressure provides favourable conditions for the preservation of C_{2+} hydrocarbons because overpressure can cause retardation of organic matter maturation (Hao et al., 2007).

Previous workers (Liu et al., 1990) deemed that the sapropelic kerogen can generate long chain hydrocarbons again at very high maturity stage, which will cause the sapropelic source rocks to show bimodal distributions of n-alkanes. Therefore the abnormal phenomenon is related to organic matter type.

Besides, cracking of bitumen also contributes to the generation of long chain hydrocarbons as there is nearly no bitumen found in all samples.

Furthermore, abnormal high thermal environment in the Wufeng-Longmaxi Formation may lead to the aromatization and cause the abnormal high contents of fluoranthene and pyrene. During the aromatization, the long chain hydrocarbons may be formed.

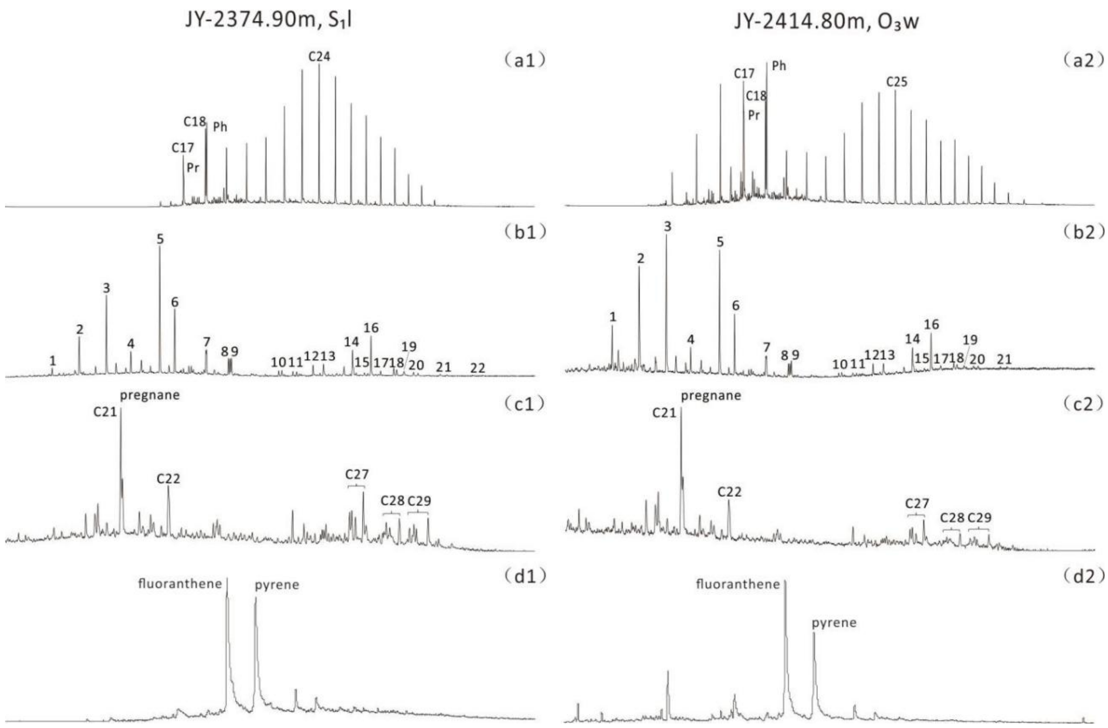

Figure 1 *distributions of n-alkanes, terpane, sterane, fluoranthene and pyrene from Wufeng-Longmaxi source rocks.S_1l, Longmaxi Formation; O_3w, Wufeng Formation; 1,$C_{19}TT$; 2,$C_{20}TT$; 3,$C_{21}TT$; 4,$C_{22}TT$; 5,$C_{23}TT$; 6,$C_{24}TT$; 7,$C_{25}TT$; 8,$C_{24}TeT$; 9,$C_{26}TT$; 10,$C_{28}TT$; 11,$C_{29}TT$; 12,Ts; 13,Tm; 14,$C_{29}H$; 15,$C_{29}Ts$; 16,$C_{30}H$; 17,$C_{30}M$; 18,$C_{31}H$; 19,Gam; 20,$C_{32}H$; 21,$C_{33}H$; 22,$C_{34}H$.*

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