

# **PS Origin Analysis on Anomalies in Enriched 25-Norhopanes in Crude Oil from the Karamay Formation of Santai Oilfield in Junggar Basin, Northwest China\***

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## **Abstract**

25-norhopanes, a series of C<sub>26</sub>-C<sub>34</sub> compounds that are structurally equivalent to the regular hopanes, has been frequently utilized to indicate severe biodegradation of crude oil. The crude oil from Karamay Formation of Santai Oilfield contained abundant 25-norhopanes, which indicated the crude oil had been severely biodegraded. As compared to other compounds, *n*-alkanes are prone to be preferentially removed in the earliest stages of biodegradation. Consequently, *n*-alkanes are depleted gradually with increasing biodegradation. However, it appeared anomalously that *n*-alkanes showed on the total ion chromatogram of the “biodegraded” oil were not significantly removed and the chromatographic baseline hump was not easily detectable. To figure out the anomaly in enriched 25-norhopanes and weakly consumed *n*-alkanes, oil-source correlation and hydrocarbon accumulation periods of the crude oil were analyzed based on the biomarkers with strong resistance to biodegradation, burial history simulation, and the analysis of fluid inclusions. The results indicated that the crude oil of the Karamay Formation originated from shales of Karamay Formation and Lucaogou Formation. In other words, the crude oil from Karamay Formation was the mixture of two source rocks.

The reservoirs of Karamay Formation in Santai Oilfield were firstly charged by hydrocarbon from shales of the Lucaogou Formation at 172 Ma. During the period of oil accumulation, the sedimentary strata were uplifted rapidly and appeared to be eroded. Consequently, the accumulated oil was biodegraded severely due to the lack of well preservation condition for oil. At 102 Ma, the reservoirs were charged by hydrocarbon from shales of the Karamay Formation again. The continuous subsidence of sedimentary strata provided a better preservation condition for oil. Therefore, the anomaly in enriched 25-norhopanes and weakly consumed *n*-alkanes was a response to the mixture of the biodegraded oil and the undegraded oil. Due to a great deal of undegraded oil charging in the later period, the signal that the crude oil from the Karamay Formation had been biodegraded was concealed by the low biodegradation degree reflected by weakly consumed *n*-alkanes.

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Peters, K. E., C.C. Walters, and J.M. Moldowan, 2005, The Biomarker Guide, Volume 2: Biomarkers and Isotopes in Petroleum Systems and Earth History, 2<sup>nd</sup> Edition, Cambridge University Press, p. 625-630.



# Origin Analysis on Anomalies in enriched 25-norhopanes in Crude Oil from the Karamay Formation of Santai Oilfield in Junggar Basin, Northwest China

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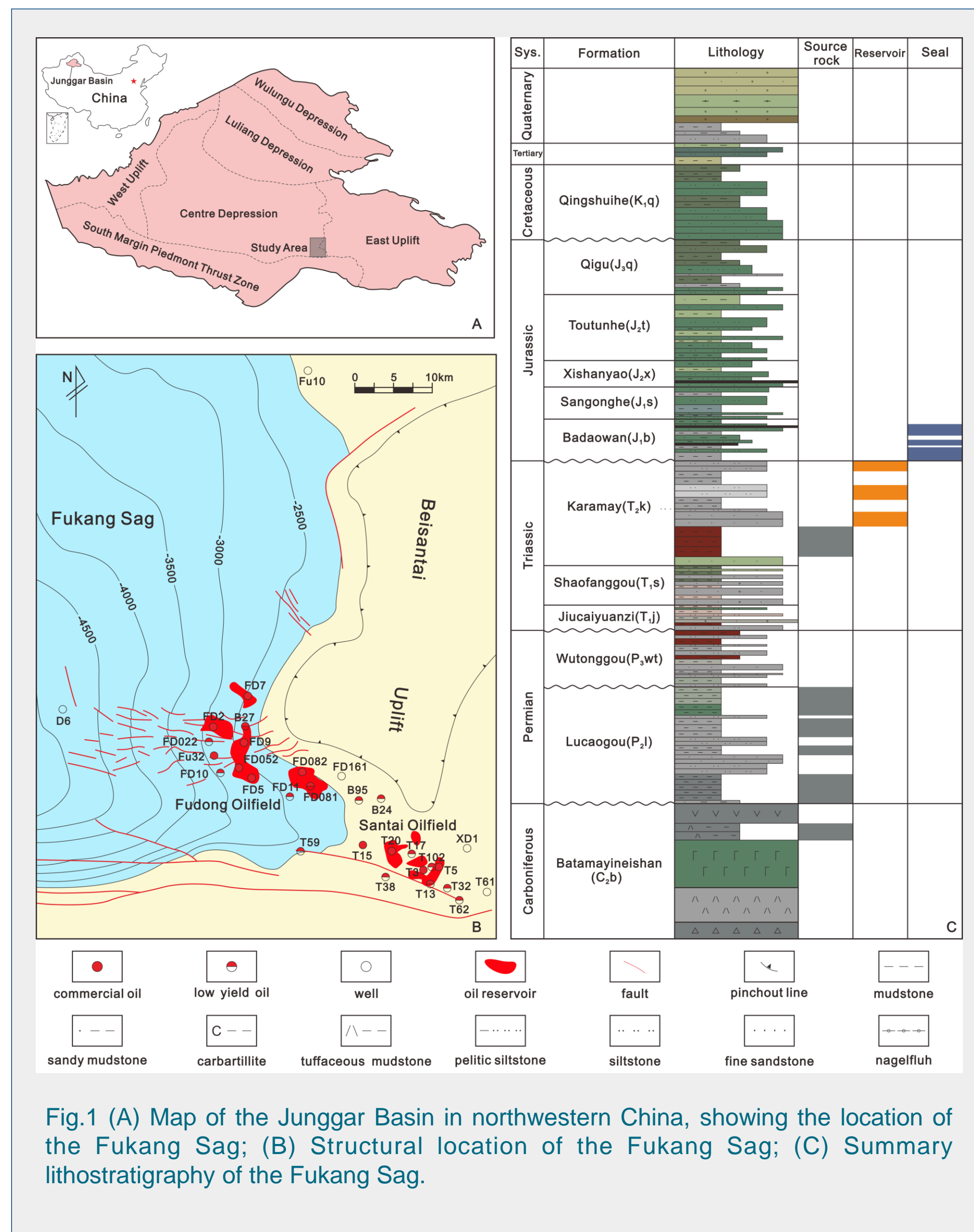


## 1. Introduction

25-norhopanes, a series of  $C_{26}$ - $C_{34}$  compounds that are structurally equivalent to the regular hopanes, has been frequently utilized to indicate severe biodegradation of crude oil. The crude oil from Karamay Formation of Santai Oilfield contained abundant 25-norhopanes, which indicated the crude oil had been severely biodegraded. As compared, n-alkanes are prone to be preferentially removed in the earliest stages of biodegradation. However, it appeared anomalously that n-alkanes showed on the total ion chromatogram of the “biodegraded” oil were not significantly removed and the chromatographic baseline hump was not easily detectable. This paper was to figure out the anomaly in enriched 25-norhopanes and weakly consumed n-alkanes.

## 2. Geological setting

The Fukang Sag was located in the eastern uplift of the Junggar Basin, which was a petroliferous area with great proven oil reserves in the Karamay Formation ( $T_2k$ ) of Triassic(Fig.1B). The Fukang Sag included sedimentary cover from Permian to Quaternary with middle Carboniferous flexure as the basement which was the result of multistage of tectonic subsidence and deposition (Ding *et al.*, 2017). The sedimentary facies of Karamay Formation were meandering river delta and lacustrine deposition, and mainly consisted of green siltstone and pelitic siltstone (Fig.1C).



## 3. Materials and methods

To figure out the anomaly in enriched 25-norhopanes and weakly consumed n-alkanes, oil-source correlation and hydrocarbon accumulation periods of the crude oil were analyzed based on the biomarkers with strong resistance to biodegradation, burial history simulation and the analysis of fluid inclusions.

## 4. Results and discussion

### 4.1 Biomarker

It appeared anomalously that the crude oil from Karamay Formation of Santai Oilfield contained abundant 25-norhopanes, but n-alkanes showed on the total ion chromatogram of the “biodegraded” oil were not significantly removed and the chromatographic baseline hump was not easily detectable (Fig2).

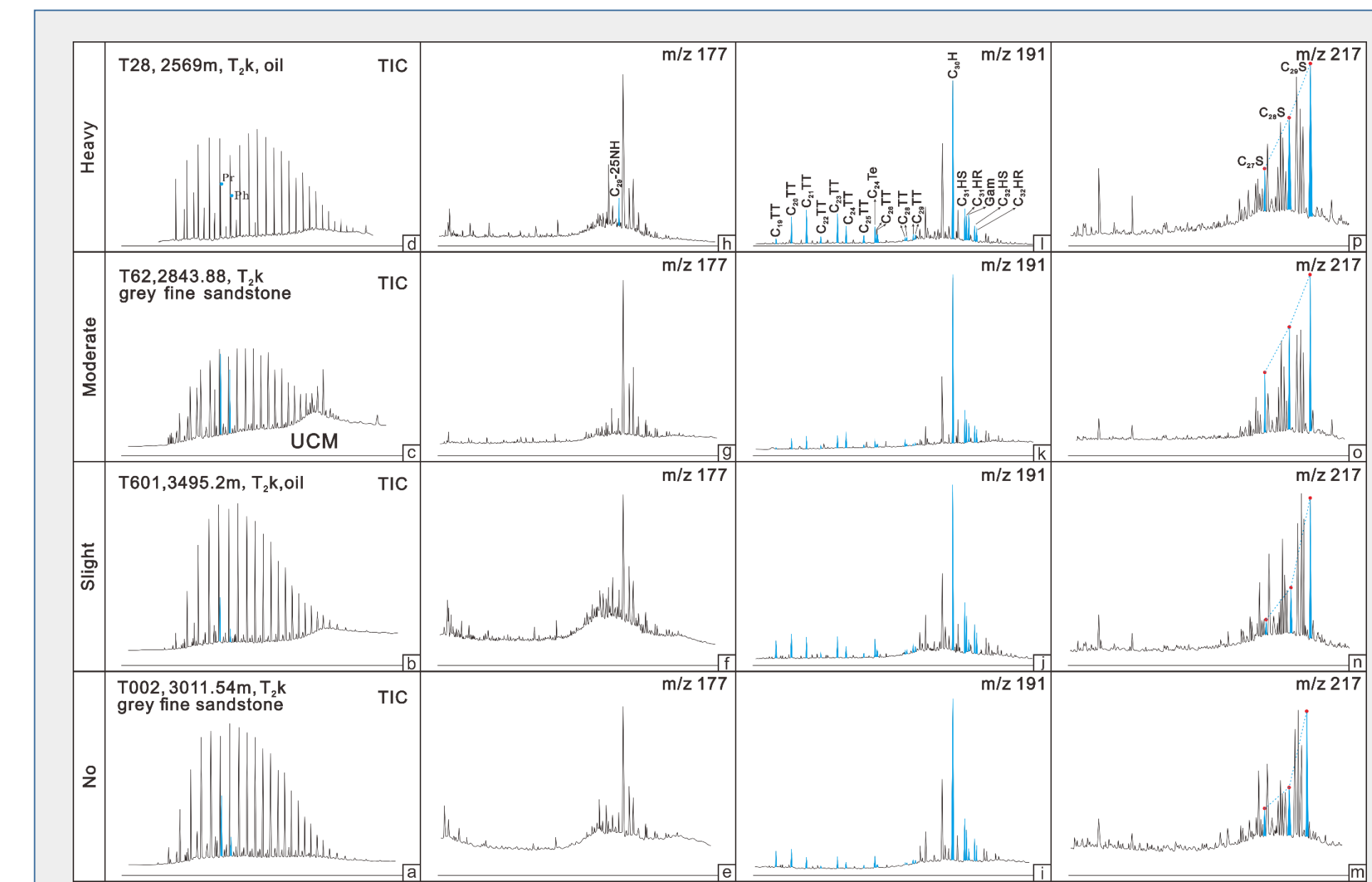


Fig.2 TIC gas chromatogram, m/z 177, m/z 191, and m/z 217 mass chromatogram of crude oils in the Karamay Formation.

### 4.2 Biodegradation

Solid bitumen was detected in the cores (Fig. 3) and brown to dark brown, blue to blue-white fluorescence color were detected from microscopic fluorescent photographs (Fig.4), which reflected that crude oil of the Karamay Formation had ever been biodegraded and was mixture originated from at least two charging phases.

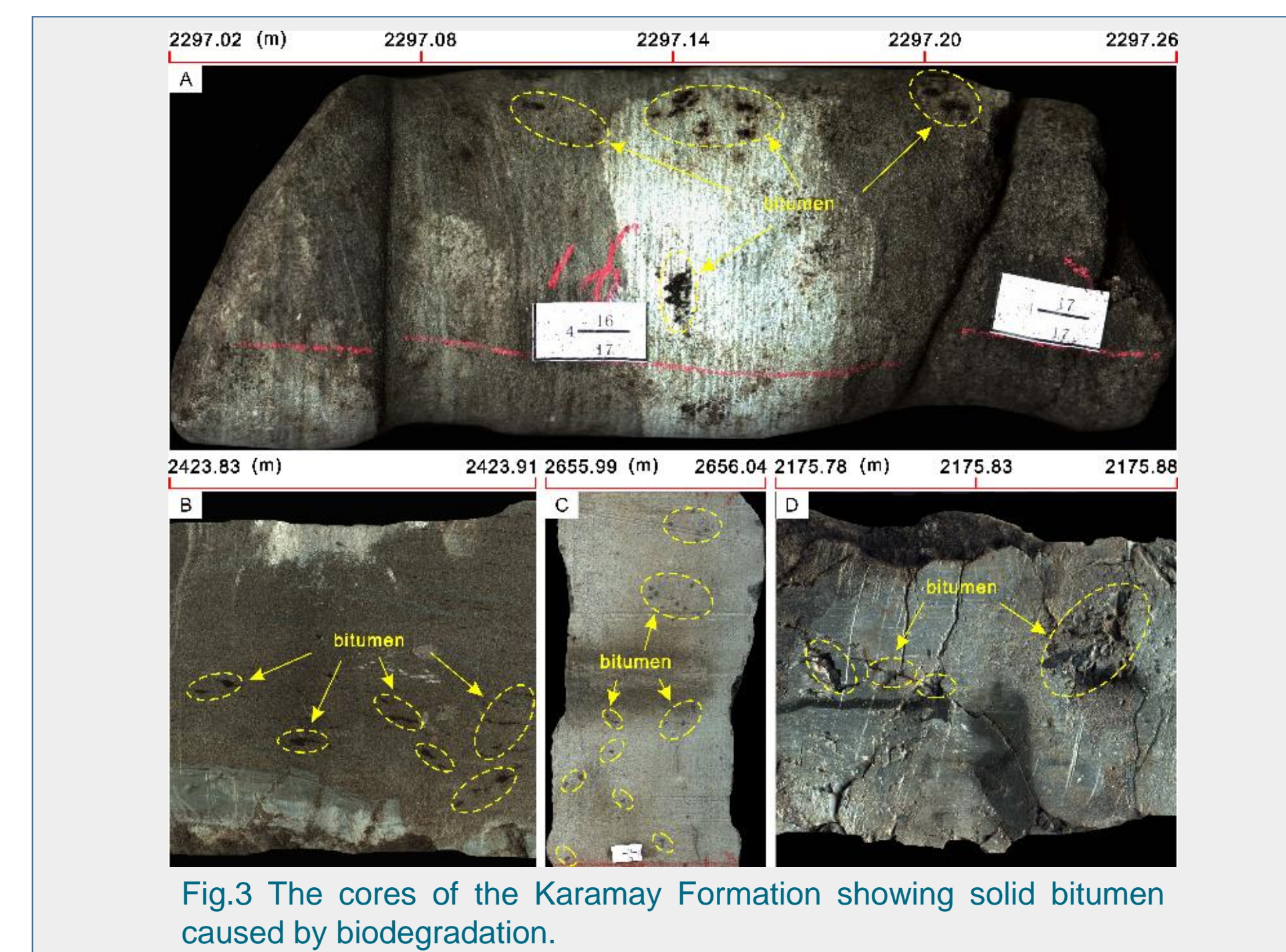


Fig.3 The cores of the Karamay Formation showing solid bitumen caused by biodegradation.

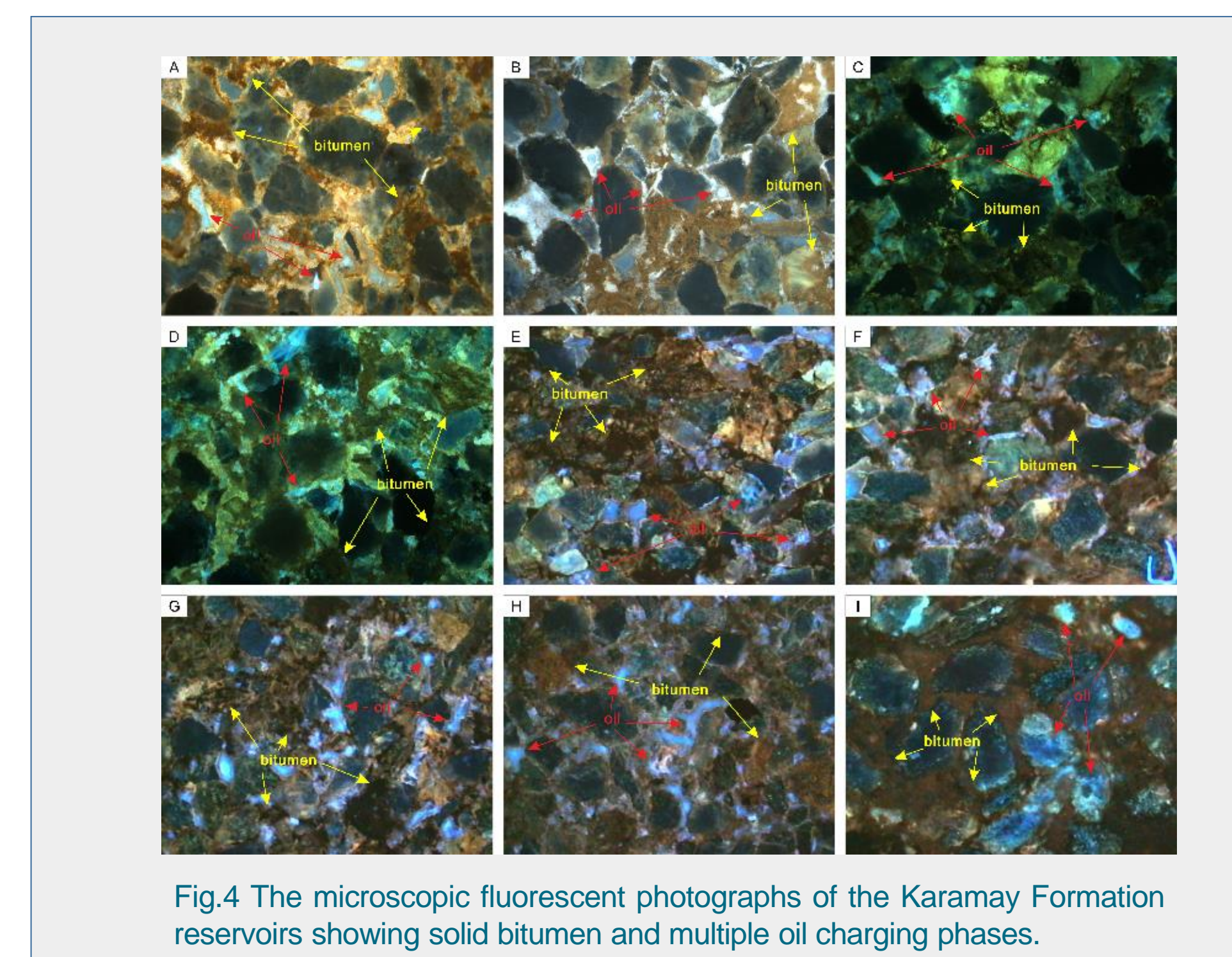


Fig.4 The microscopic fluorescent photographs of the Karamay Formation reservoirs showing solid bitumen and multiple oil charging phases.

### 4.3 Oil-source correlation

The oil-source correlation results indicated that the crude oil of the Karamay Formation originated from shales of Lucaogou Formation and Xiaoquangou Formation (Fig. 5, 6, 7).

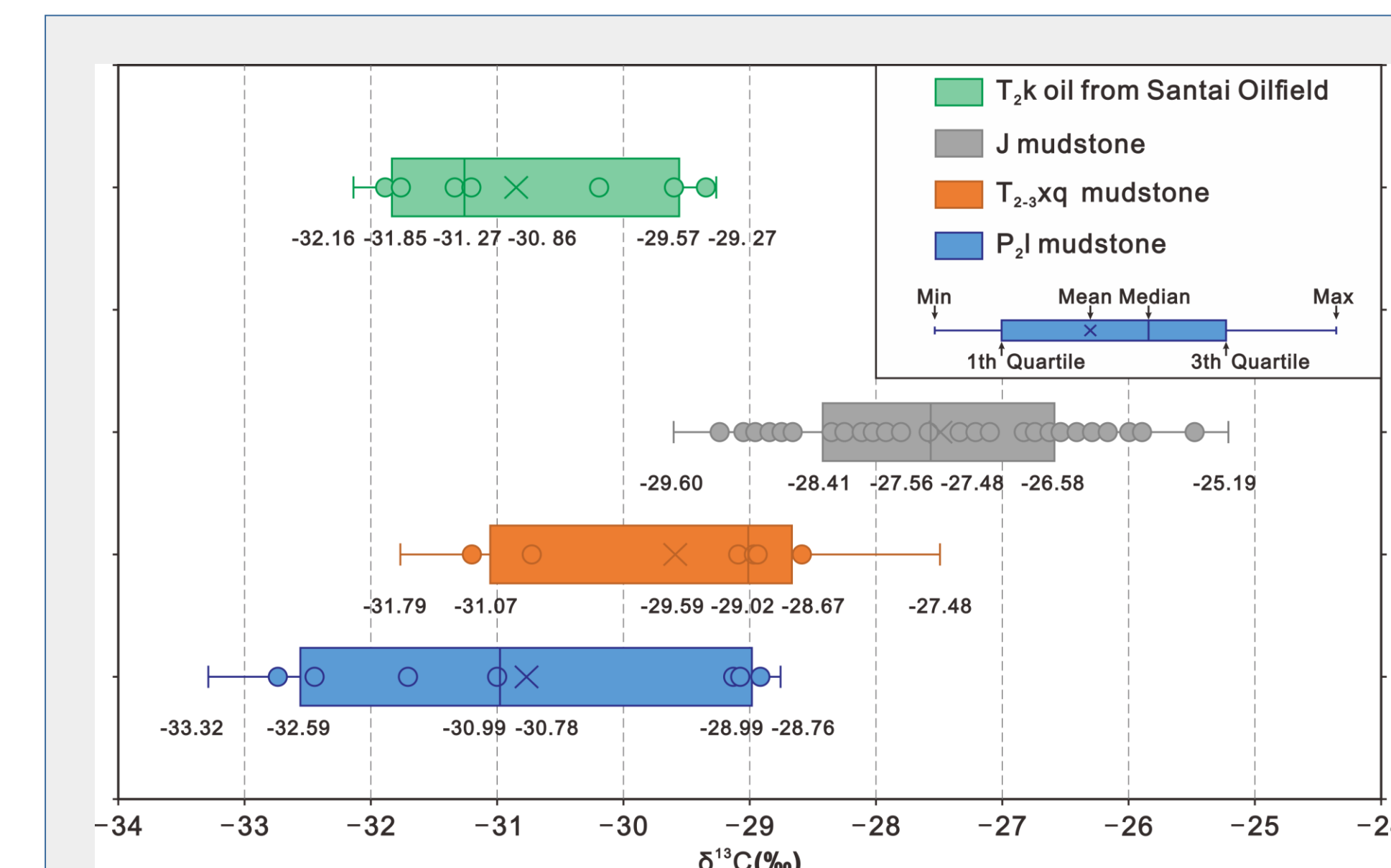


Fig. 5 The carbon isotope values of source rock and oil samples..

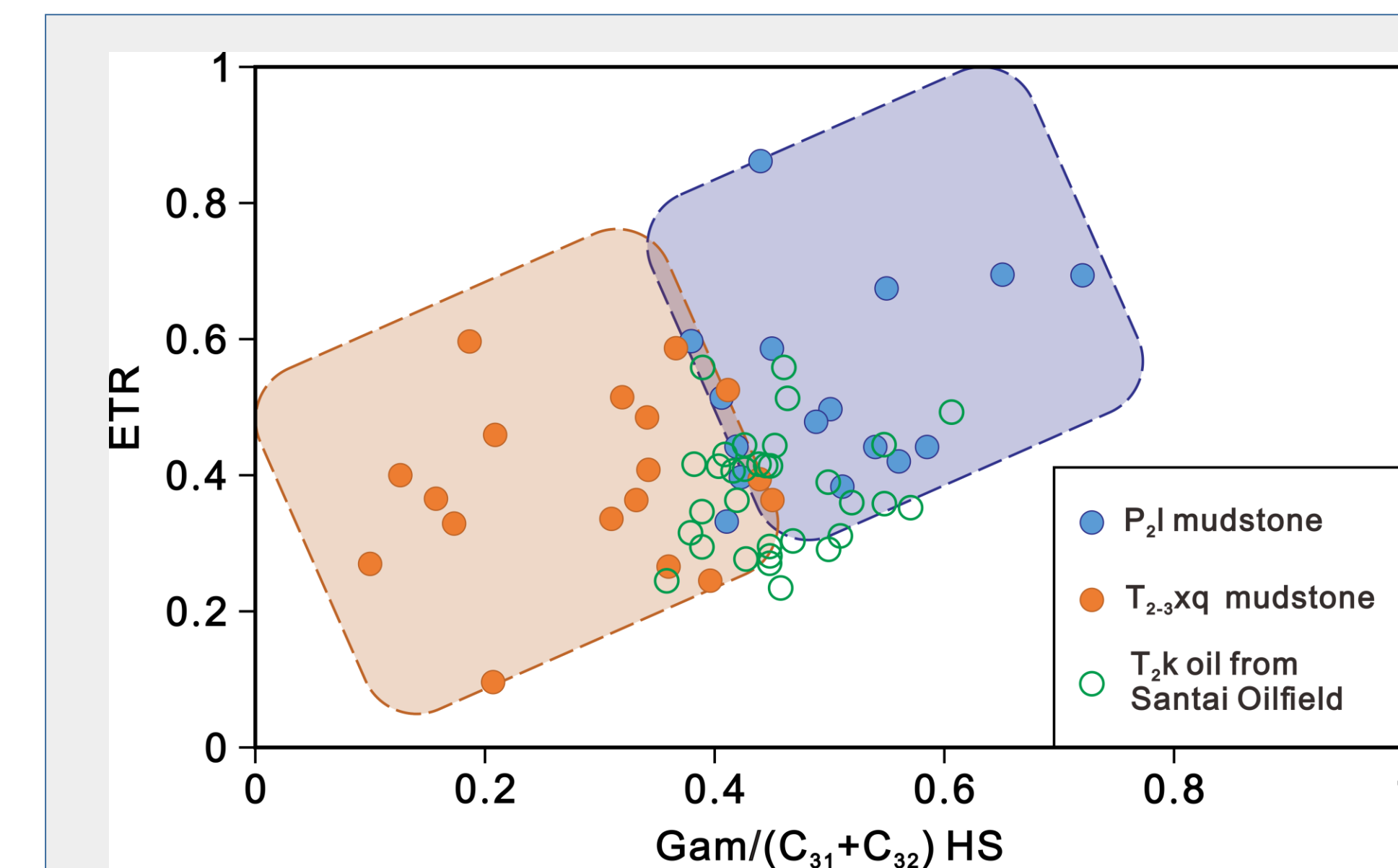


Fig.6 Gam/(C<sub>31</sub>+C<sub>32</sub>) HS versus ETR showing correlation between crude oil and source rocks.

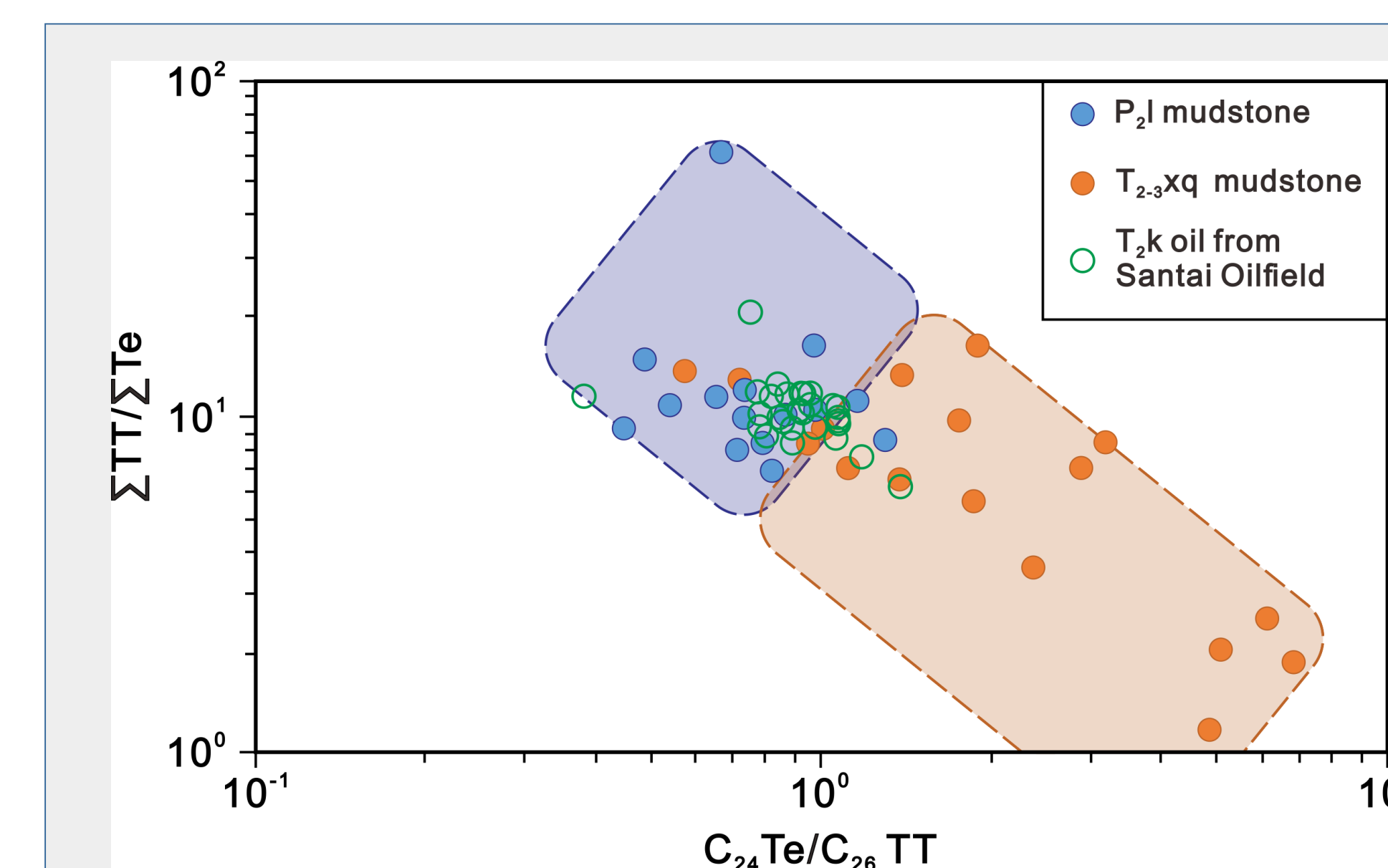


Fig.7 C<sub>24</sub>Te/C<sub>26</sub>TT versus ΣT<sub>1</sub>/ΣTe showing correlation between crude oil and source rocks.

### 4.4 Oil charging history

The analysis of oil-bearing fluid inclusions was carried out to construct oil charging history. The homogenization temperatures of the inclusions of Well T13 presented two peaks: 40°C–50°C and 80°C–90°C (Fig. 8), which revealed that two phases of oil charging occurred, respectively, in the Late Jurassic and the Middle Cretaceous (Fig.9).

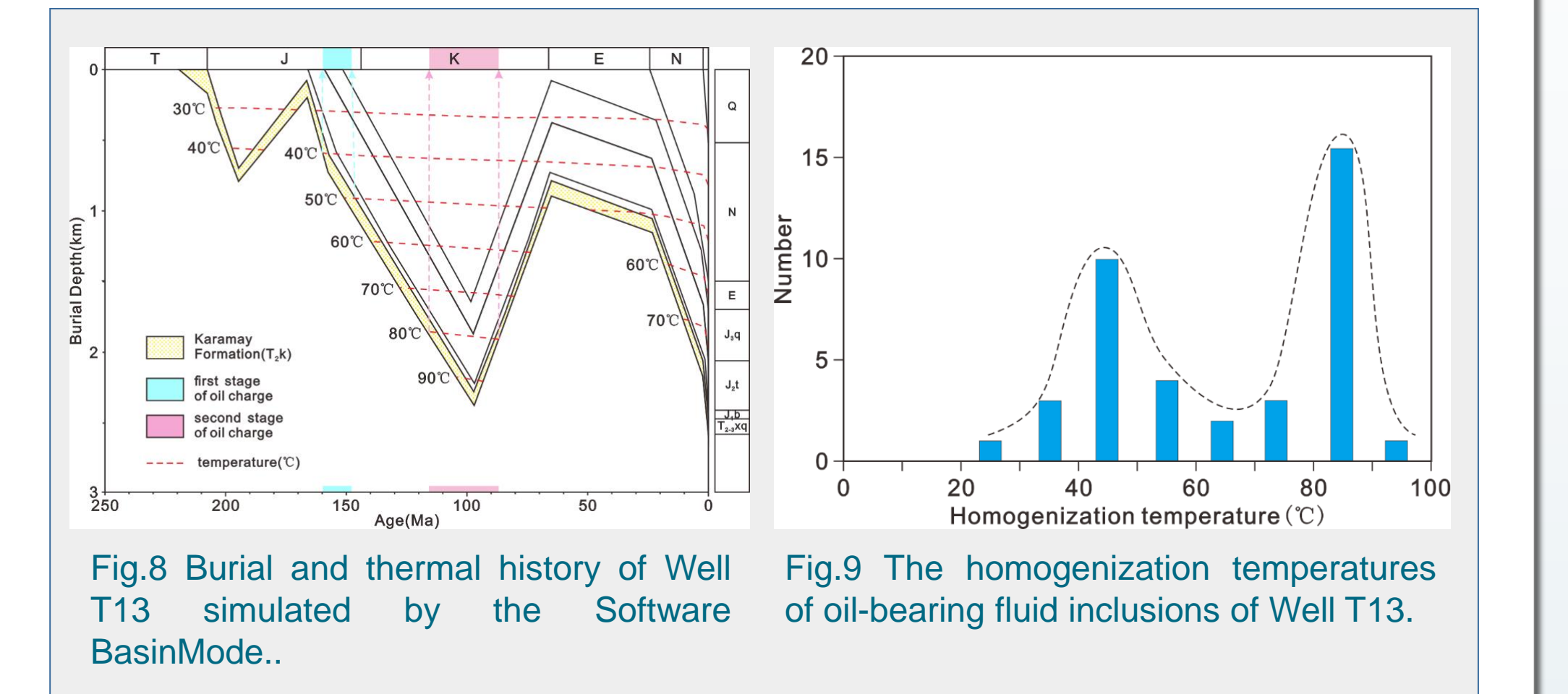


Fig.8 Burial and thermal history of Well T13 simulated by the Software BasinMod..

Fig.9 The homogenization temperatures of oil-bearing fluid inclusions of Well T13.

In the Late Jurassic, the Karamay Formation was charged by crude oil generated in the Lucaogou source rock. Due to small burial depth, crude oil was biodegraded with n-alkanes being severely removed and substantial 25-norhopanes being created. In the Middle Cretaceous, the Karamay Formation was recharged by Xiaoquangou source rock. The biodegraded oil mixed with light oil. Finally, the mixture of crude oil was characterized by enriched 25-norhopanes and weakly removed n-alkanes (Fig. 10).

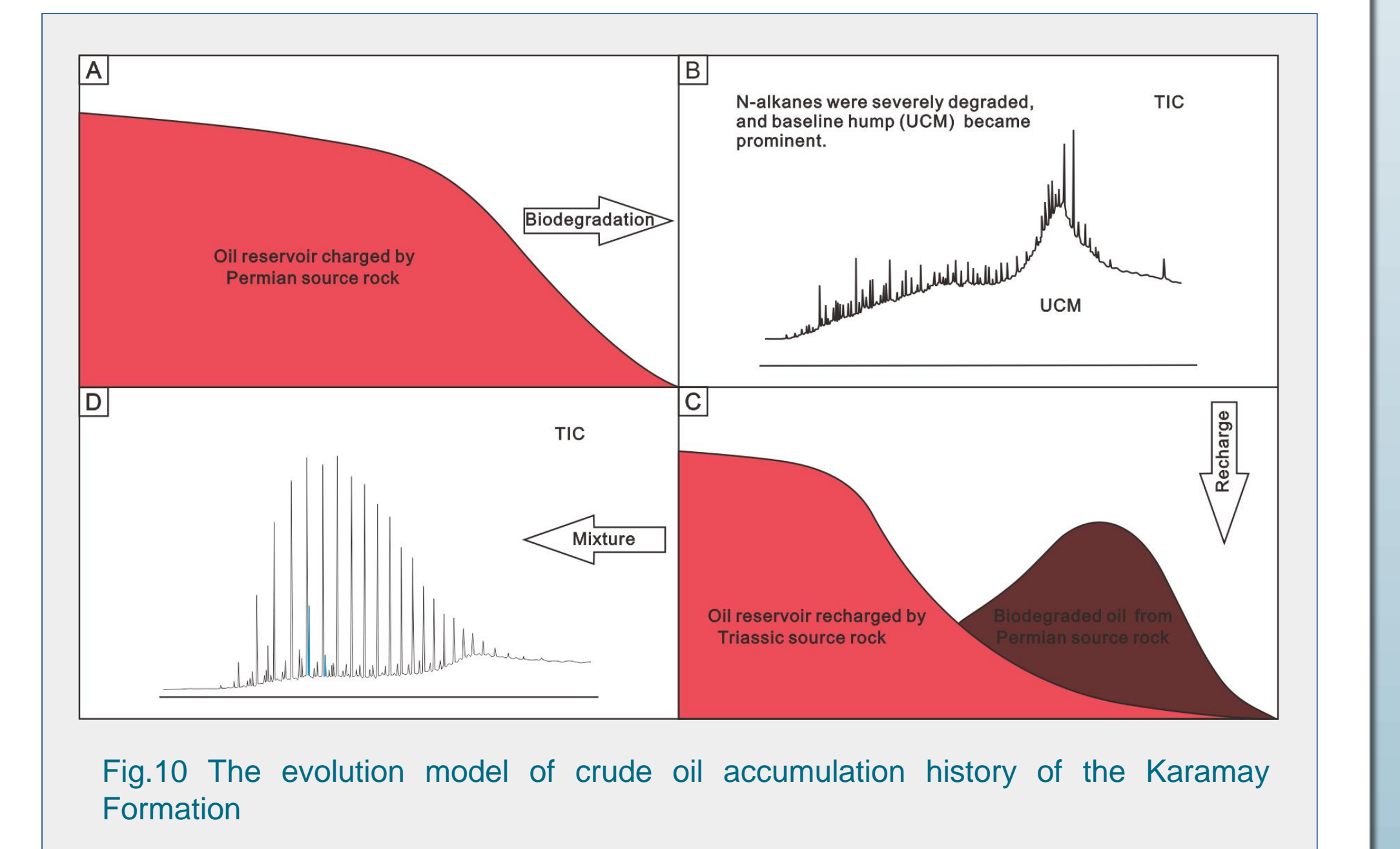


Fig.10 The evolution model of crude oil accumulation history of the Karamay Formation

## 5. Conclusions

The anomaly in enriched 25-norhopanes and weakly consumed n-alkanes was a response to the mixture of the biodegraded oil and the undegraded oil. Due to a great deal of undegraded oil charging in the later period, the signal that the crude oil from the Karamay Formation had been biodegraded was concealed by the low biodegradation degree reflected by weakly consumed n-alkanes.

## 6. References

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## 7. Acknowledgments

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