Genesis of Upper Triassic Xujiahe Formation Tight Sandstone Gas in the Northeast Sichuan Basin, China*

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Abstract

Xujiahe Formation is one of the important tight sandstone reservoirs in Sichuan Basin. Recent years showed good hydrocarbon exploration potential. However, the origin of gas in the YB- BZ–MLB field of Northeast Sichuan Basin is not entirely clear. The natural gas component is mainly composed of hydrocarbon gas with the average content of methane (CH4) being 93.41% and the natural gas drying coefficient being 0.96-0.99. The carbon isotope of CH4 has little difference ranging from -25.2‰ to 38.2‰. Furthermore, R/Ra falls in between 0.0076 and 0.01608, and 40Ar/36Ar range from 358.48 to 437.2, which all indicate typical dry gas of crustal origin. The calculated mean value of source rocks maturity is 1.90 by using Dai's δ13C1-Ro regression equation, which is in accordance with the high maturity- over maturity stage of kerogen in Xujiahe formation. The hydrogen isotope of CH4 (δDCH4) is lighter ranging from -154‰ to -174‰ (average value =-160.8‰). Those geochemical data of CH4 show the characteristics of typical coal type gas. The carbon isotopic composition of ethane (δ13C2) is in - 21.5‰--29.7‰ range also tells the coal type gas genesis from Xujiahe source rock in YB and BZ block. The partial or complete inversion of the carbon isotope series may be caused by natural gas mixing in different stages. A relatively small slope of In (C1/C2)-In (C2/C3) in YB and BZ block distinguishing from MLB block prove that natural gas origin from thermal degradation of kerogen. However, the content of δ13C2 in MLB block is less than -28.0‰ and partial or complete reversal of carbon isotope series are probably attributable to marine genetic gas by migrating to the Xujiahe reservoir along the fault and then mixing with coal type gas. It means methane and heavy hydrocarbon gas have different sources. In summary, YB –BZ block is typical coal type gas while MLB block' methane mainly comes from coal type gas of the coal-bearing source rocks in Xujiahe formation and heavy hydrocarbon gas(C2+) is mainly derived from the crude oil cracking gas in the underlying marine source rock.

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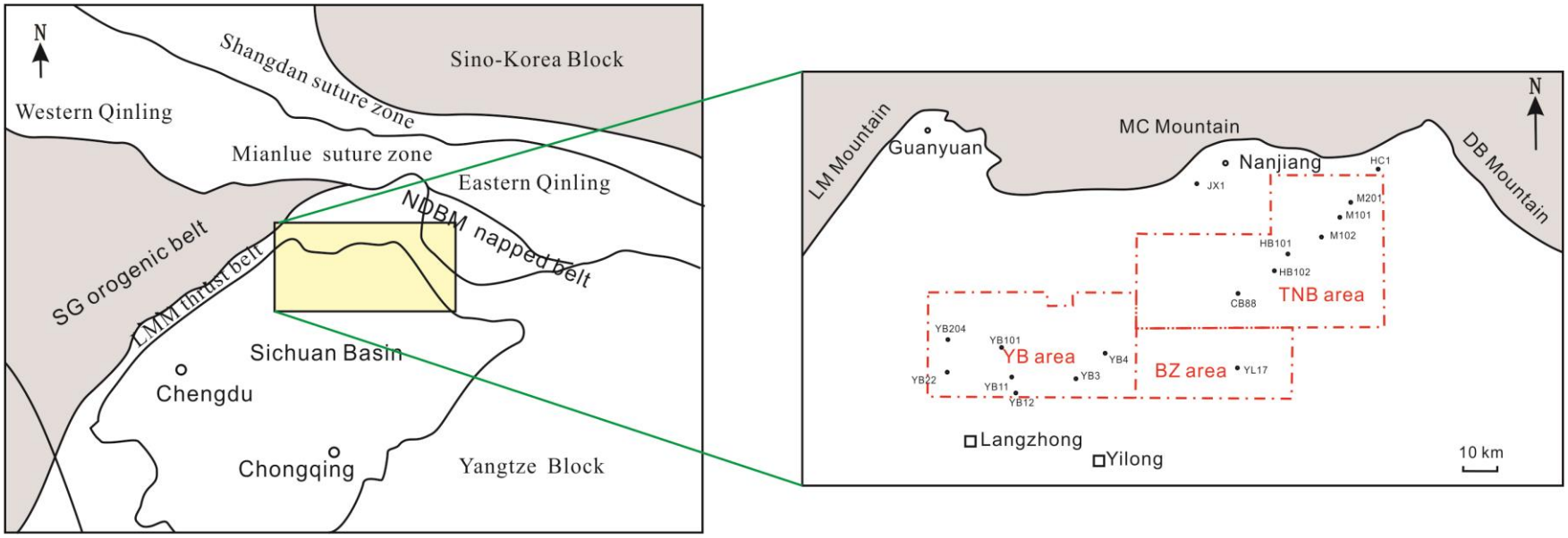
Introduction

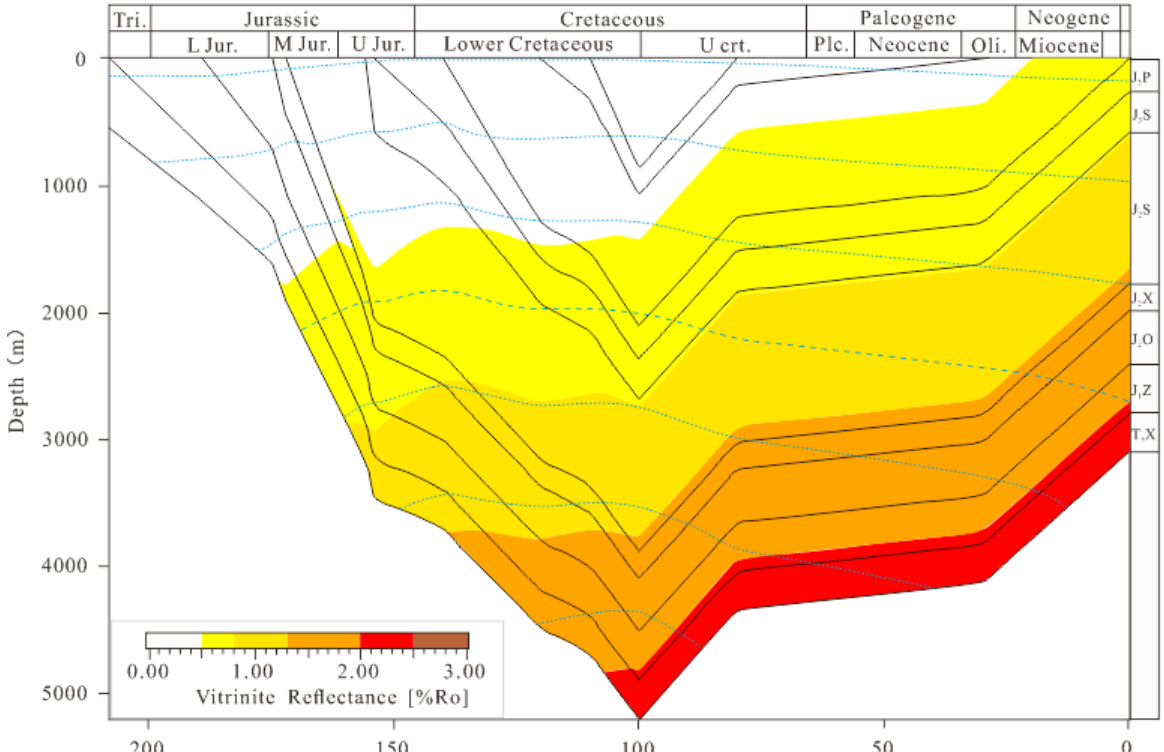
Xujiahe Formation is one of the important tight sandstone reservoirs in Sichuan Basin. Recent years showed good hydrocarbon exploration potential. However, the origin of gas in the YB- BZ–MLB field of Northeast Sichuan Basin is not entirely clear.



Facies： braided river delta sedimentary system of marine-terrestrial interaction

Source rocks: coal, dark mudstone and carbonaceous mudstone. II2 -III type and the stage of high-over maturity.

Late Jurassic-Early Cretaceous has entered the stage of large amount of gas generation.The study area underwent the superimposition of Indosinian, Yanshan, Himalayan three stages movement and developed NW-trending faults and NE-trending anticline structures.

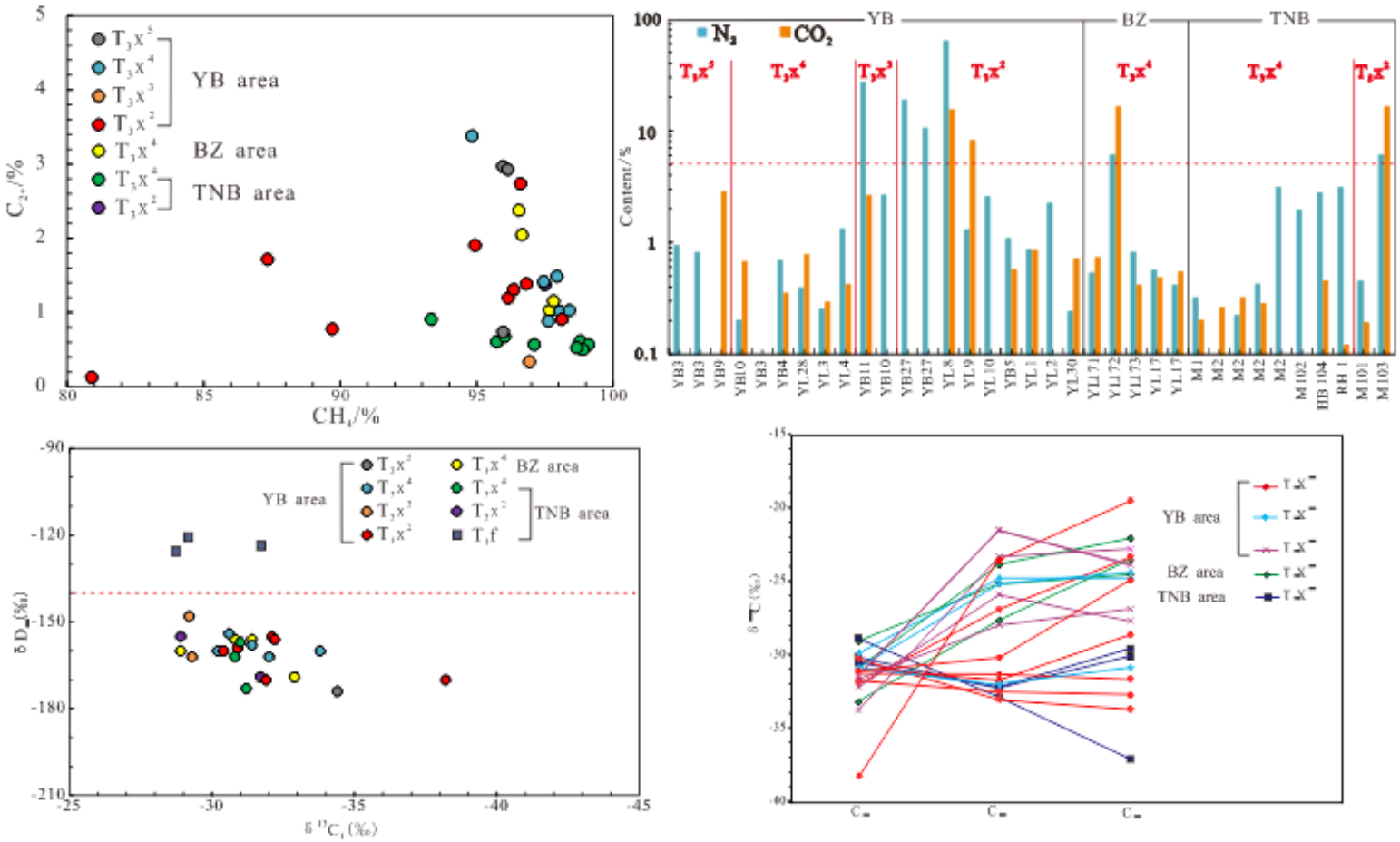


Erathem	System	Series	Formation	Mark	Lithology Profile	Thickness (m)
Mz	K	Lower Cretaceous		K_1		0 – 700
	J	Upper Jurassic	Penglaizhen	J_3p		1000 – 1400
			Suining	J_3sn		300 – 350
		Middle Jurassic	Shaximiao	J_2s		1300 – 1600
				J_2x		300 – 350
			Qiangfoya	J_2q^3		50 – 100
				J_2q^2		100 – 150
				J_2q^1		30 – 60
		Lower Jurassic	Zilijing	J_1z^4		70 – 100
				J_1z^3		60 – 150
				J_1z^2		30 – 60
				J_1z^1		200 – 300
	T	Upper Triassic	Xujiahe	T_3x^5		60 – 100
				T_3x^4		50 – 100
				T_3x^3		60 – 120
				T_3x^2		150 – 300
				T_3x^1		30 – 100
		Middle Triassic		T_2l^4		80 – 150

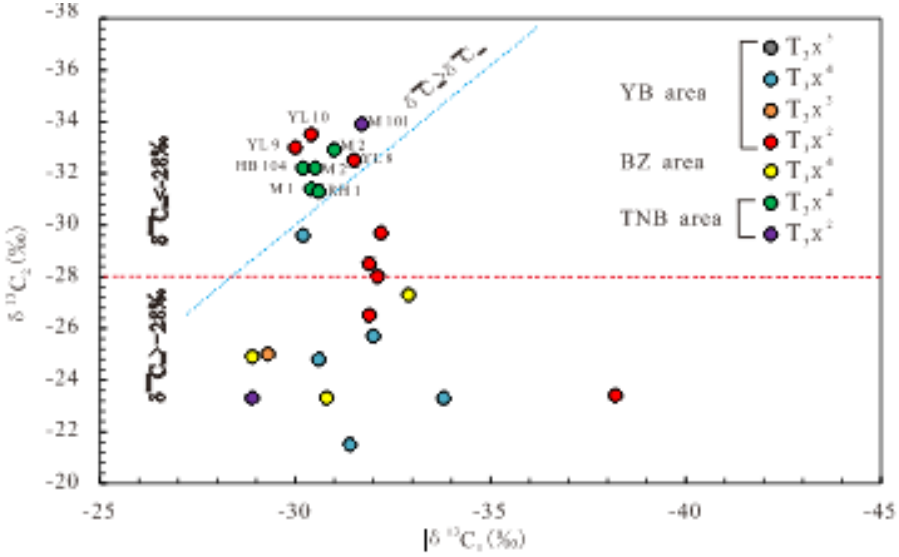
Methods

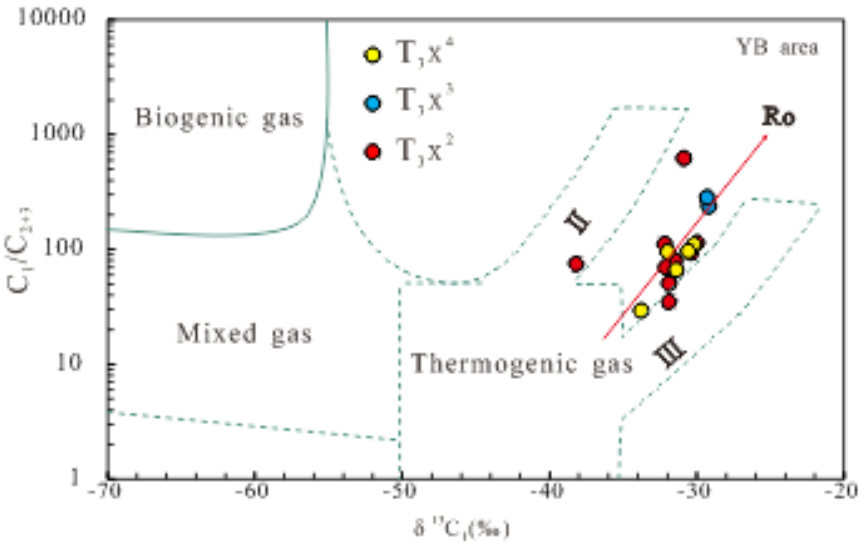
The chemical composition of gas samples were analyzed by thermal-conductivity gas chromatography. The volume percents of constituents, nitrogen, carbon dioxide, methane, ethane, propane, butane, sulfuretted hydrogen and so on, were measured.The stable carbon and hydrogen ratios measured on Finnigan MAT-251TM isotope ratio mass spectrometer are reported in notation in parts per mil (%) deviation, relative to the Peedee Belemnite (PDB) marine carbonate standard and standard mean ocean water(SNOW) standard, respectively.

The natural gas component is mainly composed of hydrocarbon gas with the average content of methane (CH4) being 93.41% and the natural gas drying coefficient being 0.96-0.99. The carbon isotope of CH4 has little difference ranging from -25.2‰ to 38.2‰. Furthermore, R/Ra falls in between 0.0076 and 0.01608, and 40Ar/36Ar range from 358.48 to 437.2, which all indicate typical dry gas of crustal origin.

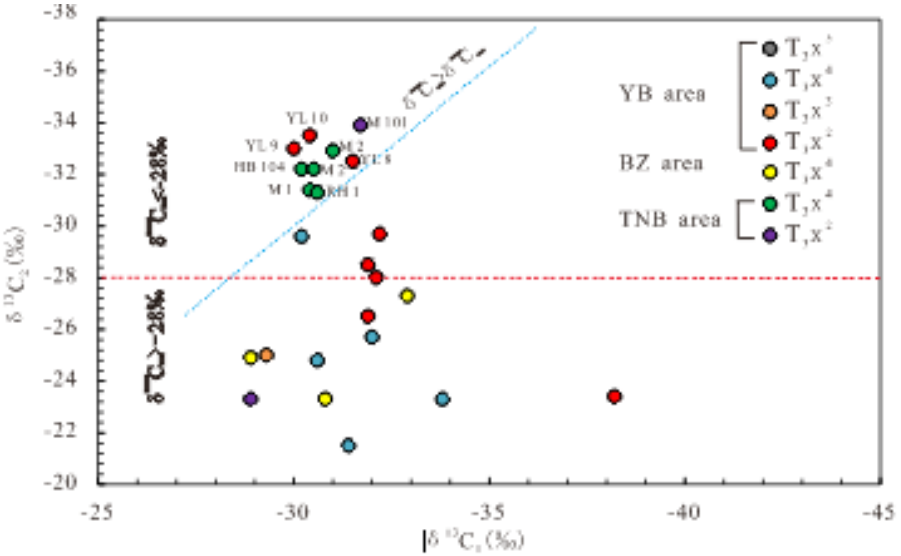


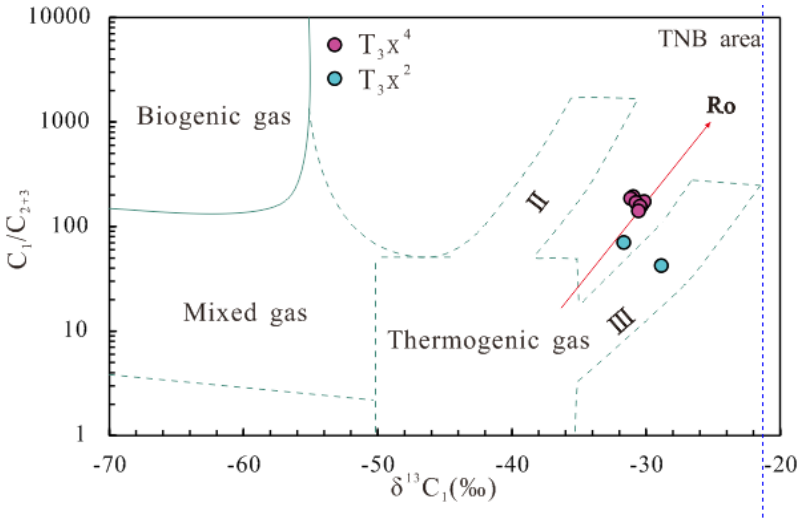
- The hydrogen isotope of CH4 (δDCH4)is lighter ranging from -154‰ to -174‰ (average value =-160.8‰). Those geochemical data of CH4 show the characteristics of typical coal type gas. The carbon isotopic composition of ethane (δ13C2) is in -21.5‰--29.7‰ range also tells the coal type gas genesis from Xujiahe source rock in YB and BZ block. The partial or complete inversion of the carbon isotope series may be caused by natural gas mixing in different stages.
- According to the identification chart of natural gas parent material type, it can be seen that the natural gas of YB area Xujiahe Formation mainly comes from type III type kerogen.





A relatively small slope of In (C1/C2)-In (C2/C3) in YB and BZ block distinguishing from MLB block prove that natural gas origin from thermal degradation of kerogen. However, the content of δ13C2 in MLB block is less than -28.0‰ and partial or complete reversal of carbon isotope series are probably attributable to marine genetic gas by migrating to the Xujiahe reservoir along the fault and then mixing with coal type gas. It means methane and heavy hydrocarbon gas have different sources.





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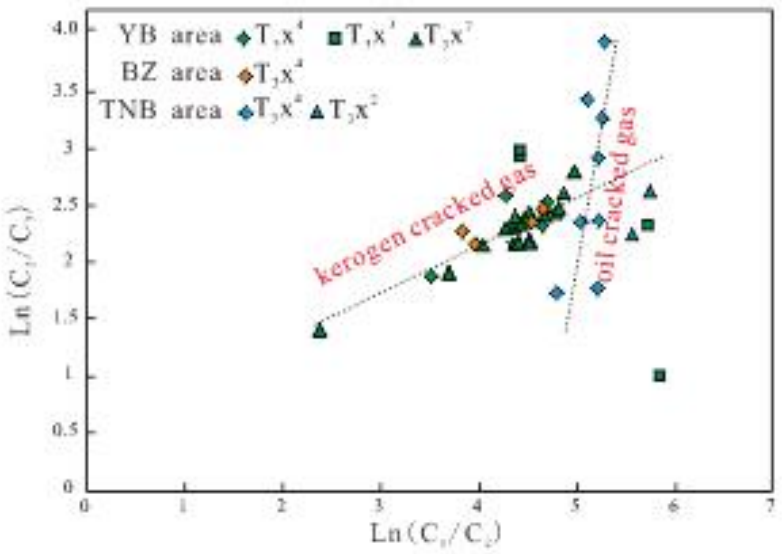

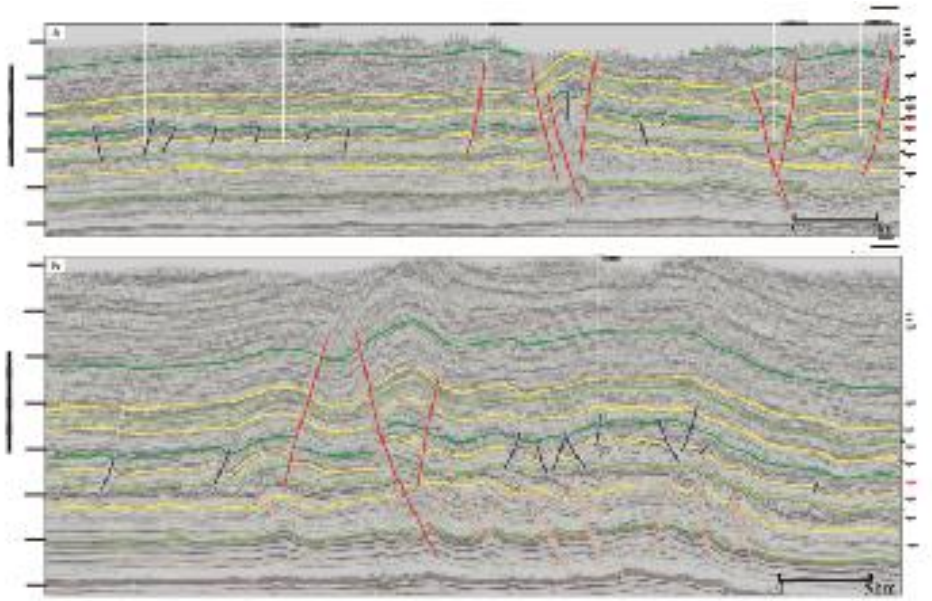

Conclusion

- **The natural gas of T3X3 and T3X4 in YB area is coal-type gas, while that of T3X2is mainly coal-type gas mixed with some oil-type gas, which mainly comes from the coal-bearing source rocks of Xujiahe Formation.**
- **The natural gas type in BZ area is typical coal-type gas, which comes from the coal-bearing source rocks of Xujiahe Formation.**
- **In MLB area exists the fault linking the underlying marine strata, the gas mixture is derived from the coal-bearing source rocks of Xujiahe Formation and the underlying marine strata.**

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