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建南气田志留系天然气地球化学特征及气源探讨

李爱荣 李净红 张金功 宋立军

摘要：

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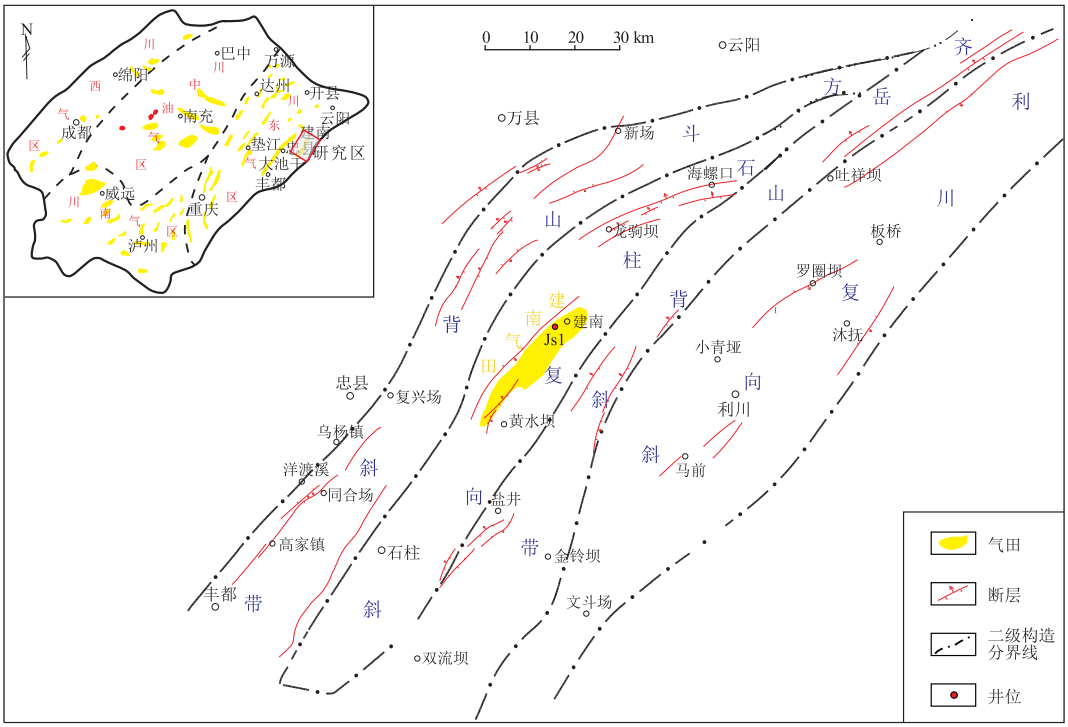

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Fig. 1 Tectonic location of Jiannan gas field and zoning of eastern Sichuan Basin

[4-9]

, Js1 ,

,

,

,

1

1.1 烃类气体组分

Js1 (S_2hj) ,

93.87% ~95.13%, (C_{2-5}) ;

C_1/C_{1-5} 0.979 1 ~0.982 2, C_1/C_{2+3} 0.473 3 ~ 0.555 4, ; (S_1l)

, 38.59% ~43.23%, , C_1/C_{1-5} 0.97 , C_1/C_{2+3} 0.299 1 ~0.337 7,

(1) C_1/C_{1-5} C_1/C_{2+3}

Js1 , (1),

C_1/C_{1-5} 0.982 2 0.967 4, C_1/C_{2+3} 0.555 4 0.299 1,

1.2 非烃气体组分

, CO_2 N_2 H_2S

CO_2 , 0.06% ~0.45%; N_2 2.37% ~4.58%,

, ,

表 1 川东地区建南气田 Js1 井志留系天然气组分对比

Table 1 Composition of natural gas from Silurian, well Js1, Jiannan gas field, eastern Sichuan Basin

	/m	/%				C_1/C_{1-5}	C_1/C_{2+3}
		CH_4	C_{2+}	N_2	CO_2		
S_2hj	3 858.13	93.87	1.70	4.37	0.06	0.982 2	0.555 4
S_2hj	3 860.00	93.53	1.75	4.58	0.02	0.981 7	0.546 9
S_2hj	3 794.56 ~3 884	95.13	2.03	2.37	0.45	0.979 1	0.473 3
S_1l	4 604 ~4 607	43.23	1.29	55.03	0.44	0.971 0	0.337 7
		38.59	1.30	59.65	0.45	0.967 4	0.299 1

,

,

2

$^{13}C_1$ -40.2 ,

, $^{13}C_1$ -55 ~ -30 ,

(2)

, ^{13}C “M ,

$^{13}C_1 > {}^{13}C_2 < {}^{13}C_3 > {}^{13}iC_4 < {}^{13}nC_4$,

,

3

3.1 天然气有机相类型

, (

) ( ) $^{13}C_1$

,

,

[10-26] ,

(: $^{13}C_1 <$

$^{13}C_2 < {}^{13}C_3 < {}^{13}C_4$) (: $^{13}C_1 >$

$^{13}C_2 > {}^{13}C_3 > {}^{13}C_4$) , $^{13}C_2$

-28

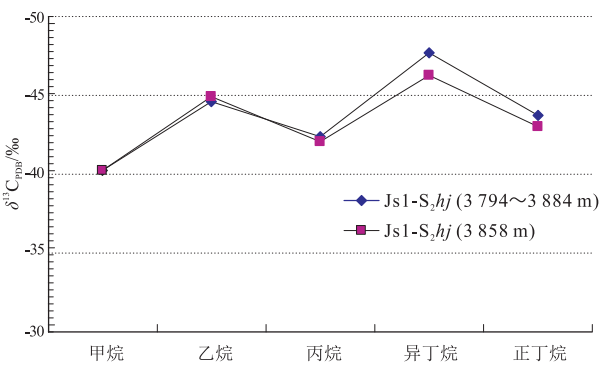
2 , Js1

C_1/C_{1-5} 98% , $^{13}C_1$

-30 ,

, CO_2 -10 ,

$^{13}C_2$ -28 ,



2 Js1

Fig. 2 Carbon isotopes of alkanes from Silurian Hanjiadian Formation, well Js1, Jiannan gas field, eastern Sichuan Basin

表 2 川东地区建南气田 Js1 井
及邻区志留系天然气碳同位素数据

Table 2 Carbon isotopes of Silurian natural gas from well Js1 and adjacent areas, eastern Sichuan Basin

		$^{13}C_1$	$^{13}C_2$	$^{13}C_3$	$^{13}C_4$	$^{13}CO_2$
Js1	S_2hj	-40.2	-44.6	-42.4	-43.7	-14.7
	S_2hj	-40.2	-44.9	-42.1	-43.0	-12.2
1	S_1l	-40.2				
	S_1l	-50.3				

: 1 [27]

$^{13}C_2$ - $^{13}C_1$ $^{13}C_2$

(

)

$^{13}C_2$ ($^{13}C_2$ - $^{13}C_1$) , Js1

(3)

3.2 天然气有机成因类型

[14,21-22,28-33] Behar

, Js1 $\ln(C_1/C_2)$

, 3.82 ~ 4.18; $\ln C_2/C_3$,

1.62 ~ 2.05, (4)

, $\ln(C_1/C_2)$

,

—

$\ln(C_1/C_2) - \ln(C_2/C_3)$,

4

,

,

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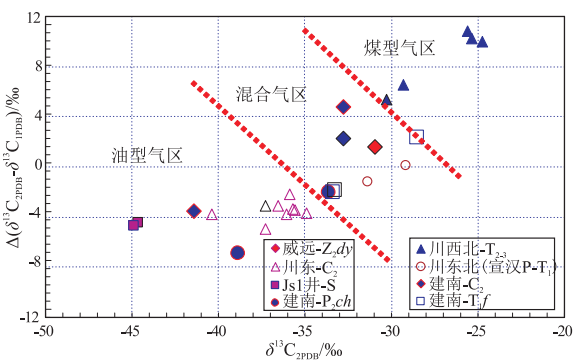
( )



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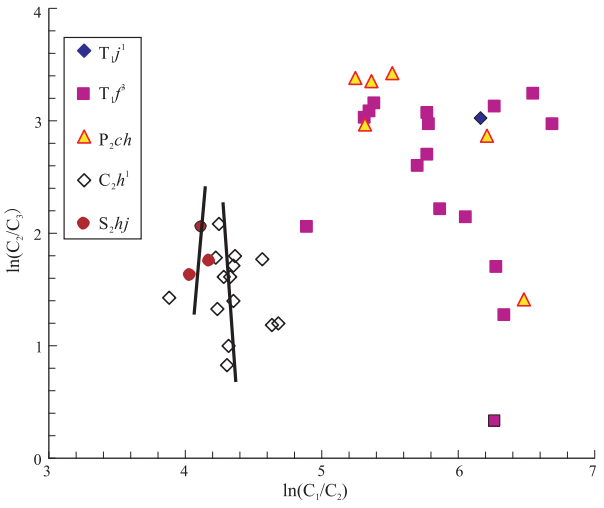
$^{13}C_2$ ($^{13}C_2$ - $^{13}C_1$)

Fig. 3 Relationship between $^{13}C_2$ and ($^{13}C_2$ - $^{13}C_1$) of natural gas from Jiannan gas field and eastern Sichuan Basin



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$\ln(C_1/C_2)$ - $\ln(C_2/C_3)$

Fig. 4 Relationship between $\ln(C_1/C_2)$ and $\ln(C_2/C_3)$ of natural gas from Jiannan gas field and eastern Sichuan Basin

— , , , , — , [1-2,33-34] Js1 , — , , , , [35-37] , , , 1 2 [38] : (1) ; (2) ; (3) ; (4) ; (5) ; (6) ^{13}C , , , 4 km $\ln(C_1/C_2)$ - $\ln(C_2/C_3)$, Js1 $^{13}C_1 > {}^{13}C_2$ $^{13}C_2$,

, , , (CH_4 93.47% , N_2 4.12% , CO_2 0.79% , C_1/C_{1+} 98.31 , $^{13}C_1$ -35.0 ~ -37.9 , $^{13}C_2$ 32.76 ~ -41.44) [19,27,39] , (4) , , [39] ^{13}C , , , , , ,

参考文献：

[1] , , , . [J]. : ,2012, 34(6):27-37.
Ma Wenxin, Liu Shugen, Huang Wenming, et al. Reservoir rocks characters of Silurian and its unconventional gas prospection in Western Hubei - Eastern Chongqing [J]. Journal of Southwest Petroleum University: Science & Technology Edition, 2012, 34(6):27-37.

[2] , , , . [J]. ,2008,29(5):589-596.
Xiao Kaihua, Li Shuanjian, Wang Xinwei, et al. Hydrocarbon accumulation features and exploration direction in the Silurian of the Middle - Upper Yangtze Platform [J]. Oil & Gas Geology, 2008,29(5):589-596.

[3] , . JZI [J]. ,2013,26(1):18-20.
Rong Yanshan, Shen Jincai. Interpretation of tight sandstone gas reservoirs of Silurian system of well - JZI in Western Hubei and Eastern Chongqing [J]. Journal of Jianghan Petroleum University of Staff and Workers, 2013,26(1):18-20.

[4] , , , . [J]. ,2013,35(4):18-29.
Feng Chong, Zou Huayao, Guo Tonglou, et al. Evaluation of source rocks in Upper Permian Wujiaping Formation of northeast Sichuan and its adjacent area [J]. Journal of Earth Sciences and Environment, 2013,35(4):18-29.

[5] . [J].

, 2015, 36(1): 1-6.
Wang Zhigang. Breakthrough of Fuling shale gas exploration and development and its inspiration[J]. Oil & Gas Geology, 2015, 36(1):1-6.

[6] , , , .
[J]. ,2013,20(2):154-156.
Zhang Qin, Wang Hongyan, Bai Wenhua, et al. Restoration of organic matter type in Silurian marine shale, South China[J]. Fault-Block Oil & Gas Field, 2013, 20(2):154-156.

[7] , . [J].
,2014,35(1):10-18.
Han Keyou, Sun Wei. Conditions for the formation of large marine gas fields and gas field clusters in Sichuan Basin[J]. Oil & Gas Geology, 2014, 35(1):10-18.

[8] , , , , . —
[J]. ,2014,36(2):10-17.
He Lijuan, Huang Fang, Liu Qiongying, et al. Tectono-thermal evolution of Sichuan Basin in Early Paleozoic[J]. Journal of Earth Sciences and Environment, 2014, 36(2):10-17.

[9] , , , , . —
[J]. ,2014,21(6):697-700.
Zhang Qingfeng, Gao Tangjun, Liu Yanting, et al. Analysis on hydrocarbon accumulation characteristics of Changxing - Feixianguan Formation in Micang Montain leading edge[J]. Fault-Block Oil and Gas Field, 2014, 21(6):697-700.

[10] , . [J].
,1996,14(1):110-115.
Liu Wenhui, Xu Yongchang. Genetic indicators for natural gases[J]. Acta Sedimentologica Sinica, 1996, 14(1):110-115.

[11] , .
[J]. :D : ,2007,37(2):1-11.
Zhang Shuichang, Zhu Guangyou. Natural gas origins of large and medium-scale gas fields in China sedimentary basin[J]. Science In China: Series D: Earth Sciences, 2008, 37(S2):1-11.

[12] . [J].
,2011,31(12):1-6.
Dai Jinxing. Significance of the study on carbon isotopes of alkane gases[J]. Natural Gas Industry, 2011, 31(12):1-6.

[13] , , , , .
[J]. ,2014,41(1):1-13.
Dai Jinxing, Yu Cong, Huang Shipeng, et al. Geological and geochemical characteristics of large gas fields in China [J]. Petroleum Exploration and Development, 2014, 41(1):1-13.

[14] , . [J].
,1992,14(3):217-226.
QianZhihao, ChenZhenfu. On the origin of the natural gas in the northern Tarim basin [J]. Experimental Petroleum Geology, 1992, 14(3):217-226.

[15] , , , .
[J]. , 2007, 29 (6): 577-582.
Guo Jianjun, Chen Jianfa, Zhu Lei, et al. Geochemical characteristics and genesis of the natural gas in the Tazhong Uplift, the Tarim Basin [J]. Petroleum Geology & Experiment, 2007, 29(6):577-582.

[16] , , .
[J]. ,2014,25(1): 53-61.
Wu Xiaoqi, Tao Xiaowan, Liu Jingdong. Geochemical characteristics and genetic types of natural gas from Lunnan area in Tarim Basin[J]. Natural Gas Geoscience, 2014, 25(1):53-61.

[17] , , , .
[J]. ,2009,30(1):46-50.
Liu Quanyou, Jin Zhijun, Wang Yi, et al. Genetic type and distribution of natural gas in Tarim Basin[J]. Acta Petrolel Sinica, 2009, 30(1):46-50.

[18] , , .
[J]. ,2010,31(3):335-342.
Wang Xiang, Zhang Min, Liu Yuhua. Origins of natural gas in Tazhong area, the Tarim Basin and their differences[J]. Oil & Gas Geology, 2010, 31(3):335-342.

[19] , , , .
[J]. ,2000, 11(2):10-17.
Wang Shunyu, Dai Hongming, Wang Haiqing, et al. Natural gas geochemistry characters and origin of large gas field in marine carbonates of the Sichuan Basin[J]. Natural Gas Geoscience, 2000, 11(2):10-17.

[20] , , , .
[J]. ,2001,23(2):115-121.
Dai Jinxing, Xia Xinyu, Wei Yanzhao, et al. Carbon isotope characteristics of natural gas in the Sichuan Basin , China[J]. Petroleum Geology & Experiment, 2001, 23(2):115-121.

[21] , , , .
[J]. ,2002,24(6):512-516.
Liu Guangxiang, Tao Jingyuan, Pan Wenlei, et al. Genetic types of the natural gas in the northeast and the east of Sichuan basin[J]. Petroleum Geology & Experiment, 2002, 24(6):512-516.

[22] , , , , . [J].
,2006,13(2):234-248.
Zhu Guang you, Zhang Shui chang, Liang Ying bo, et al. The characteristics of natural gas in Sichuan basin and its sources[J]. Earth Science Frontiers, 2006, 13(2):234-248.

[23] . [J].
,2008,19(1):1-7.
Ma Yongsheng. Geochemical characteristics and origin of natural gases from Puguang gas field on eastern Sichuan Basin[J]. Natural Gas Geoscience, 2008, 19(1):1-7.

[24] , , .
[J]. ,2011,32(54):867-872.
Wang Qiangl, Xu Liheng, Chen Jianfa. Characteristics and origin of natural gas in large and medium sized gas reservoirs in northeast Sichuan Basin[J]. Oil & Gas Geology, 2011, 32(54):867-872

[25] , . :
[J]. ,2013, 35(6):601-606.

Guo Shaobin, Huang Lei. Gas-bearing influential factors and evaluation of shale gas reservoir: A case study of Paleozoic shale gas reservoir in Upper Yangtze region [J]. Petroleum Geology & Experiment, 2013, 35(6): 601-606.

[26] , , , . — [J]. , 2014, 34(3): 44-49.
Wei Guoqi, Xie Zengye, Bai Guilin, et al. Organic geochemical characteristics and origin of natural gas in the Sinian-Lower Paleozoic reservoirs, Sichuan Basin [J]. Natural Gas Industry, 2014, 34(3): 44-49.

[27] , , , . [J]. , 2009, 29(5): 45-50.
Wang Shejiao, Wang Lansheng, Huang Jinliang, et al. Accumulation conditions of shale gas reservoirs in Silurian of the Upper Yangtze region [J]. Natural Gas Industry, 2009, 29(5): 45-50.

[28] Behar F, Ungerer P, Kressmann S, et al. Thermal evolution of crude oils in sedimentary basins: experimental simulation in a confined system and kinetic modeling [J]. Oil & Gas Science and Technology-Rev. IFP, 1991, 46(2): 151-181.

[29] Prinzhofer A A, Huc A Y. Genetic and post genetic molecular and isotopic fractionations in natural gases [J]. Chemical Geology, 1995, 126(3/4): 281-290.

[30] , . : [J]. , 2000, 46(6): 646-650.
Zhao Mengjun, Lu Shuangfang. Natural gas from secondary cracking of crude oil: an important pattern of gas generation [J]. Geological Review, 2000, 46(6): 646-650.

[31] , , , . [J]. , 2001, 19(1): 156-160.
Yin Changhe, Wang Tingdong, Wang Shunyu, et al. Differences between kerogen and oil cracked gases in Sinian reservoirs of Weiyuan and Ziyang area [J]. Acta Sedimentologica Sinca, 2001, 19(1): 156-160.

[32] , , . [J]. , 2011, 33(4): 428-436.
Guo Liguo, Xiao Xianming, Tian Hui. Laboratory studies of differences between oil-derived and kerogen maturation gases [J]. Petroleum Geology & Experiment, 2011, 33(4): 428-436.

[33] , . — [J]. , 2010, 31(6): 659-664.
Li Yanxia, Li Jinghong. Exploration prospects of shale gas of Upper Sinian-Silurian in Mid Yangtze region [J]. Xinjiang Petroleum Geology, 2010, 31(6): 659-664.

[34] , , , . — [J]. , 2011, 30(2-3): 349-356.
Li Yanxia, Lin Juanhua, Long Youkang, et al. Exploration prospect of gas bearing marine mudstone-shale in Lower Palaeozoic in the Central Yangtze area [J]. Geological Bulletin of China, 2011, 30(2/3): 349-356.

[35] , , , . [J]. : , 2009, 36(6): 621-630.
Xu Guosheng, Cao Junfeng, Zhu Jianmin, et al. Division of fluid compartments and the formation and evolution of oil and gas accumulation in the typical structures of Western Hubei-Eastern Chongqing area, China [J]. Journal Of Chengdu University Of Technology: Science & Technology Edition, 2009, 36(6): 621-630.

[36] , . [J]. , 2011, 16(3): 38-44.
Hu Xiaofeng, Ding Qing. Evolution of Silurian fluid compartments and gas accumulation in Western Hubei-Eastern Chongqing area [J]. Marine Origin Petroleum Geology, 2011, 16(3): 38-44.

[37] , , . [J]. , 2008, 30(4): 37-72.
Wang Shaohua, Wan Yuqiang, Lin Juanhua. Genetic type of natural gas of marine facies in Jiannan gas field [J]. Journal of Oil and Gas Technology, 2008, 30(4): 37-42.

[38] , , , . [J]. , 2003, 24(1): 1-6.
Dai Jinxing, Xia Xingyu, Qin Shengfei, et al. Causation of partly reversed orders of ^{13}C in biogenic alkane gas in China [J]. Oil & Gas Geology, 2003, 24(1): 1-6.

[39] , , . [J]. , 2010, 31(5): 710-717.
Dai Jinxing, Ni Yunyan, Huang Shipeng. Discussion on the carbon isotopic reversal of alkane gases from the Huanglong Formation in the Sichuan Basin, China [J]. Acta Petrolei Sinica, 2010, 31(5): 710-717.

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