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Generation and Accumulation of Marine Gases in the Himalayan: Taking the Tarim Basin as An Example

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In the Tarim basin, the Paleozoic was consisted by shallow metamorphic marine clastic rocks, quartz and carbonate (Jia et al., 2007); Marine source rock is mainly developed in the Cambrian and Ordovician, the source rocks is mainly composed of shale and marl; the types of reservoir are sandstone reservoir and carbonate reservoir (Zhang et al., 2009). In the marine strata, the large gas reservoir (Hetiante gas field) and eastern Lungu condensate have been discovered in succession. Recently, a number of new discoveries have been achieved during the strengthen exploration around the Tazhong Ⅰ slope zone, such as commercial condensate was proved in the well Tazhong-83, weathering crust reservoir of lower Ordovician, and rich in hydrogen sulfide; And high-yield reservoir was also discovered in the mud limestone of Ordovician in Well Tazhong-72, etc. The preliminary evaluation showed that the symbiosis of large oil and gas fields might exist in the Tazhong Ⅰ slope belt. Compared with the Sichuan basin, marine gases in Tarim basin were mostly characterized by condensate reservoirs, the large marine pure gas reservoirs were only found in the Carboniferous of Hetianhe area. And, the dry coefficient of marine gas reservoirs in the Sichuan basin accumulation was abnormally high (mostly dry coefficient greater than 0.99), moisture components of gas was generally less than 0.5% (Table1). The differences of the PVT phase and physical properties between gas reservoirs of the Sichuan basin and Tarim basin were mainly related with the different geological conditions in the two marine craton basins, such as types of source rocks, stratigraphic lithology, thermal evolution history and tectonic cycles, etc (Jia et al., 2006).

Marine gas reservoirs of the Tarim basin were mainly distributed in northern and central, two inherited palaeohigh. Through the comparison of isotopic characteristics, it could be demonstrated that carbon isotopic is positive sequence arrangement with the carbon number in the centre of Lunnan area (Fig.1), which conforms to the normal kerogen evolution characteristics of hydrocarbon generation. However, the carbon isotopic of gases in the western lunnan area lighter than -41‰, which indicated the origin of biodegradation (Fig.1). Especially in eastern lungu area, the dry coefficients of gases were 0.98 greater than those of any other area of Lunnan uplift. The isotopic composition of gases is antitone sequence arrangement with the carbon number, and the distribution of carbon isotope value is consistent, $\delta^{13}C_1 > \delta^{13}C_2 < \delta^{13}C_3$ (Fig.1), carbon isotope of methane form -36‰ to -34‰, carbon isotope of ethane form -37.5‰ to -34.5‰, and carbon isotope of propane form -30.2‰ to -34.7‰. It was showed that the gas of condensates is likely to be invaded with high mature oil-cracking gas. And, the gases in the reservoirs of overlying Carboniferous and Triassic are also appearance of the differences between the eastern and western. However, according to the result of oil-source correlation, the oil-source of three sets of main oil-bearing strata is mainly consistent (Zhang et al., 2000). Therefore, the diversity of petroleum properties in different areas is likely caused by the various secondary changing after the initial accumulation. The condensate reservoirs of eastern Lungu might experience a more complex formation process. Meanwhile, the dry coefficient, gas-oil ratio and carbon isotopic of methane gradually reduced in the reservoirs from the Ordovician to Triassic, which might signal the gas charging direction from deep to shallow strata.

Two sets of marine source rocks mainly developed in the Paleozoic group of Tarim basin, which had experienced multi-phase hydrocarbon generation and accumulation, multi-period adjustment and transformation in the long process of geologic evolution history (Zhang et al., 2005). On the one hand, multi-layer composite and superimposed petroleum system developed; on the other

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Table 1 Geochemical characteristics of marine gases in the Tarim basin and Sichuan Basin (Reserves volume >300×10^{8}m^3)

Basins	Gas Fields	Reservoirs	Proved reserves (×10^{8}m^3)	CH_4(%)	C_1/C_1^+	$\delta^{13}C_1$(‰)	$\delta^{13}C_2$(‰)	Origin type
Sichuan	Puguang	T_1f, P_2	2510.7	76.42	0.999	-30.47	-27.4	Coal, Marine shale
	Luojiazhai	T_1f	581.08	81.6	0.999	-30.38	-29.4	
	Wubaiti	C_2, P_2	409	96.6	0.991	-31.8	-35.51	Marine shale
	Weiyuan	P_1, Z_2	408.61	86.58	0.999	-32.5	-31.95	
	Shapingchang	C_2	397.71	95.17	0.995	-32.31	-36.12	
	Wolonghe	C, P, T	380.52	91.82	0.995	-32.84	-35.59	
Tarim	Eastern Lungu	O_{2-3}	499.51	91.71	0.992	-34.8	-37.5	Marine shale
	Tazhong I	O_1	2821.48	86.05	0.971	-54.4	-38.2	
		O_{2-3}	972.61	82.35	0.961	-38.5	-36.6	
	Hetianhe	C	616.94	78.72	0.965	-37.2	-36.48	

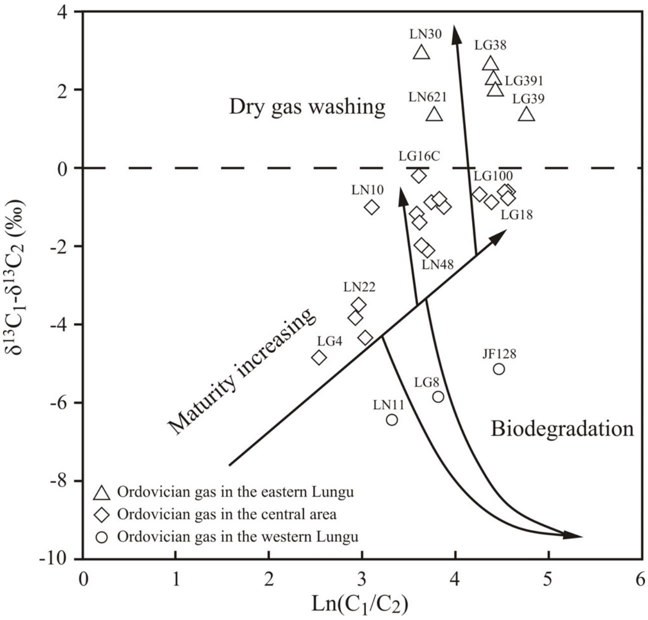

Fig.1. The relationship diagrams between relative amount and isotopic characteristics of CH_4 and C_2H_6 in the northern Tarim basin

hand, mixture of multi-source was obvious. It was indicated that the Caledonian to early Hercynian, the late Hercynian and late Himalayan were the three key geological periods for the formation of such a complex petroleum system, based on the comprehensive research of basin evolution, hydrocarbon generation and the history of accumulation and adjustment (Li et al., 2009). The first two periods is given priority to oil accumulation, but the late Himalayan is given priority to gas charging. And the ancient reservoirs have experienced the adjustment, renovation and destruction in the late Himalayan.

In the late Caledonian (about 400Ma), tectonic movement of Tarim basin was much intense and kept a long time (Wei et al, 2002), which made Silurian and Ordovician strata corroded in the uplift area. In this period, the petroleum reservoirs had been almost damaged. Nowadays, it could be discovered that traces of asphalt. Dating data of authigenic illite in the asphalt sandstone released that the charging of petroleum happened between 376~383Ma. Based on the analysis data of hydrocarbon inclusions, the late Hercynian is the most important period of petroleum accumulation in the north Tarim basin. But the tectonic uplift before Triassic sedimentary made different degrees of damage to the reservoirs (Chen et al., 1997), structural high port of reservoir had been damaged and periclinal area experienced biodegradation.

Especially since 20 Ma ago, thick Cenozoic covered on the sedimentary combination of Paleozoic and Mesozoic (Li et al, 2007), so that the evolution of marine source rocks and the generation of hydrocarbons had been accelerated. Cambrian hydrocarbon source rocks in the Manjia'er sag entered over-mature phase, the gases generated form oil-cracking, migrated and charged from east to west. The high-yield gas-wells are mainly distributed in the eastern region, along the deep and large fracture. It was indicated that the late high-maturity gases came from the deep. This stage of the gas charging washed early oil reservoir, which brought about the formation of secondary condensates reservoir. In the northern Tarim, the condensates of eastern lungu originated from the gas washing in the late Himalayan. The oil-cracking gas was much dry. when them charged and intruded into ancient reservoirs, one side displace the black oil in the reservoir, these black oil migrated upward and accumulated in the overlying stratigraphic trap along faults (Molnor, 1998), ether effused and accumulated in the updip direction of reservoir along carrier bed (Yu et al., 2004). On the other hand, the charging dry gases dissolved some black oil, which leaded to form second condensates. In this kind of second condensates, components of hydrocarbons show the typical characteristics of dry and heavy density. And, the PVT diagram of reveroirs released the phase of condensate. Meanwhile, a small amount of oil ring was also residual at the bottom of the condensates reservoir. The geochemical characteristics of the second condensates were impacted by the tectonic movement in the late Himalayan.

Key words: the late Himalayan, marine gases,

generation and accumulation, oil-cracking, Tarim basin

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