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Geochemical Characteristics and Origin of Natural Gases from the Feixianguan-Changxing Formation in the Northern Sichuan Basin

Jinxing Dai, Guoyi Hu, Yunyan Ni & Zengye Xie
 Research Institute of Petroleum Exploration and Development, Petrochina, Beijing, China

The Feixianguan-Changxing Formation in the Northern Sichuan Basin has great gas potential. Several large gas fields have been found in the carbonate reservoirs, which were distributed in both sides of the Kaijiang-Liangping Seaway, such as Puguang, Luojiashai, Dukouhe, Tieshanpo gas fields in the northeast of the seaway and Yuanba, Longgang and Tieshan gas fields in the northwest of seaway. The Puguang gas field is one of the largest marine carbonate reservoir gas fields in China. The proved gas reserves of the Yuanba and Puguang gas fields may be also more than 100 billion cubic meters. But the carbon and hydrogen compositions of gases in these gas fields vary greatly and the origin of gas should be investigated. The results will help us to determine which petroleum system is favorable for gas exploration in this area.

More than thirty gas samples have been collected and analyzed in this study. The composition of the natural gases studied is dominated by methane ranging from 63.50% to 99.40% with an average value of 88.23%. The cumulative content of the higher hydrocarbons from ethane to pentane is low. CO₂ content changes greatly from 0 to 22.46% with the average of 5.87% and H₂S content is from 0 to 41.4% with the average of 6.44%. The carbon isotope values of methane range from -33.6‰ to -26.8‰ with an average of -30.1‰. The δ¹³C₂ ranges from -35.1‰ to -21.7‰ with an average of -27.9‰. Hydrogen isotopes are very heavy. The δD₁ value ranges from -129‰ to -98‰ and δD₂ is from -102‰ to -89‰.

Geochemical characteristics of gases in the Northwest of Kaijiang-Liangping Seaway are different from that in the northeast. The content of H₂S is higher in the northeast than that in the northwest. But the carbon and hydrogen isotopes are lower in the northwest (Table 1).

Table 1: The geochemical data of gases in the northwest and northeast of the Seaway

Location	Gas field	H ₂ S%	δ ¹³ C ₁ ‰	δ ¹³ C ₂ ‰	δD ₁ ‰
Northwest	Yuanba	0~7.9/3.7	-29.7~-27.9/ 28.6	-25.3~-25.2/ 25.3	-114~-113/ 114
	Longgan	0~9.1/2.8	-31.7~-27.5/ 29.6	-28.9~-21.7/ 24.6	-115~-108/ 112
Northeast	Puguan	5~14.9/10.2	-32.4~-29.4/ 30.2	-31.5~-25.2/ 29.5	-129~-115/ 121
	Luojiashai	8.3~10.4/9.3	-30.7~-30.3/ 30.5	-29.4	-

Carbon isotope is useful indicator of gas origin. Based on chemical compositions and isotopic compositions, thermogenic gases can be clearly subdivided into coal-derived and oil-associated gas. The $\delta^{13}\text{C}_2$ values of gases in the northwest Seaway are very heavy, over -28‰ . These indicate that gases are mainly coal-derived gas. Coal beds in the Longtan Formation distribute in the study area. The $\delta^{13}\text{C}_1$ and $\delta^{13}\text{C}_2$ values of gas from Longtan Formation in well PG2 are -30.6‰ and -25.2‰ respectively. The gases in the northwest Seaway are similar to well PG2, so these gases possibly originated from the Longtan coal measures. But the ethane carbon isotopes of gases in the northeast of Seaway are very light. For example, $\delta^{13}\text{C}_2$ values range from -31.5‰ to -25.2‰ and most of them are less than -28‰ , which indicate an oil-associated gas origin. Both $\delta^{13}\text{C}_1$ values and the content of H_2S are very high, which demonstrate that gases in the northeast Seaway may be from oil-cracking gas. However, the $\delta^{13}\text{C}_2$ value of gas from the Changxing Formation in Well PG2 is very heavy and it indicates that gases in Puguang gas field were mixed partly by coal-derived gas.

The study of origin of gases from the Changxing-Feixianguan Formation shows that there are two sets of petroleum systems in the Northern Sichuan Basin and the distribution of gases was controlled by these two petroleum systems.