AAPG HEDBERG CONFORENCE
"NATURAL GAS GEOCHEMISTRY: RECENT DEVELOPMENTS, APPLICATION, AND TECHNOLOGIES"
MAY 9-12, 2011 – BEIJING, CHINA

Genetic Types and Accumulation Characteristics of Biogases in Jiyang Depression

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In recent years, many shallow-buried and small scaled biogas reservoirs have been found in Jiyang Depression, and the total geological reserves are estimated $450\times10^8 m^3$ (Gao et al, 2010). Because of the complex geological conditions and developed faults, many shallow gas reservoirs in Jiyang Depression are characterized by coexistence of biogas and thermogenic gases with different genetic types (Gao et al, 2010), so identifying the genetic types of biogases is important for exploration and development in Jiyang Depression. In this paper, we study the gas geochemistry characteristics and accumulation geological background and classify the biogas into two genetic types, the source rock-derived biogas and oil-degraded biogas (Gao et al, 2009). In addition, the identifying parameters of each type of biogas are given. Based on the analysis above, the accumulation characteristics and their distributions of each type of biogas are studied, which helps to exploration for the biogases in different basins.

1. Geochemistry characteristics and genetic types

The methane content of source rock-derived biogas is between 79.10% and 98.87%, the ethane and higher alkane (C_{2+}) content is very low (most of them are less than 0.2%), the C_1/C_{2+} ratio ranges from 179.8 to 9641, and most of them are large than 500. The methane carbon isotopic is less than -55‰(PDB). Carbon dioxide and nitrogen are the major non-hydrocarbon components of biogases. Nitrogen content has significant changes from 0.77% to 7.38%, and the carbon dioxide content is from 0.08% to 13.9% (Table 1).

The ethane and higher alkane (C_{2+}) content of oil-degraded biogas vary widely, the highest up to 0.49, and the minimum is only 0.05, the methane carbon isotope range from -50 to -60‰, and the carbon isotope sequences reversed, and the carbon isotope of propane is abnormal heavy (Table 1).

Table 1. Geochemical characteristics and genetic types of biogas in Jiyang Depression

Region	Well	Formation	Depth (m)	Gas Components%				$\delta^{13}C_1$‰ (PDB)	$\delta^{13}C_2$‰ (PDB)	$\delta^{13}C_3$‰ (PDB)	$\delta^{13}C_4$‰ (PDB)	C_1/C_{2+}	Genetic
				CH_4	C_{2+}	N_2	CO_2						
Yangxin Sag	Y101	Es_1	1504	98.40	0.17	1.04	0.39	-60.6				578.8	rock-derived biogas
	Y15	Es_1	1412	97.16	0.08	1.69	0.10	-60.9				1214.5	
	Y16	Es_1	1309	97.76	0.18	1.95	0.10	-56.5				543.1	
Huagou	H4	Es_1	1307	89.25	0.17	7.38	0.29	-55.4				525.0	
	H171	Es_1	1453	79.10	0.14	6.78	13.9	-55.1	-33.2	-31.3	-29.8	179.8	
Dongxin	QD9	Nm	966	96.29	0.04	3.62	0.04	-55.1				2407.3	
	QD5	Nm	1013	96.41	0.01	2.49	1.09	-55.6				9641.0	
	Q9	Es_2	1509	98.87	0.15	0.77	0.08	-57.7	-30.6	-26.3	-21.1	197.7	
Yihezhuang	YG74	AnZ	1515	70.25	0.19	26.72	2.84	-58.9				369.7	Oil Degraded
Chenjiazhuang	CQ8	Nm	945	94.39	0.47	4.88	0.35	-53.9	-25.7	-27.1	-29.0	200.8	
	CQ11	Nm	935	96.46	0.41	3.02	1.01	-50.9	-20.1	-33.1	-18.5	235.3	
	C53	Nm	935	95.35	0.49	4.02	0.14	-50.4	-21.2	-25.9	-22.6	194.6	
Shanjiasi	SQ10	Nm	824	95.56	0.06	2.27	1.01	-54.2				1592.7	
	SQ11	Ng	822	93.22	0.06	6.66	0.07	-51.2				1553.7	
	SQ15	Nm	830	98.66	0.05	1.23	0.06	-52.4				1973.2	

2. Accumulation characteristics

The rock-derived biogas is derived from biodegradation of organic matter in source rocks by microbial. Such biogases source rocks are shallow-buried with low thermal maturity (Ro <0.4%), rich in organic matter, and has a suitable environment for microbial proliferation.

Yangxin Es_1 biogas is typical of such biogas, taking it as an example. The source rocks of the Es_1 biogas in the Yangxin Sag are grey mudstones and dark-grey oil shales with Ro between 0.27% and 0.35%, and the TOC contents between 0.22% and 11.80%. First, the organic matters in source rocks are fermented into small molecules such as organic acids by *Fermentative bacteria*, and then these small molecules are used by *methanogens* and change into methane mainly by CO_2-reduction (Whiticar et al,1986). The source rocks have been in the biogas generation stage since Ng. A series of traps are developed on the slope and structural highs, just updip on the source kitchen, and are charged fully with the biogas. The reservoirs are mainly bioclastic limestones and dolomites deposited in lakeshore or sand sheet facies with high porosity and permeability with a caprock of the lacustrine mudstones.

The biogases in the Yangxin Sag migrated in water-soluble or diffused mode. The migration distance is short because the biogases diffuse easily in rocks with weak diagenesis. Biogases are mostly accumulated in the central uplift near the sags. In the central uplift, many traps developed, which were suitable for gas capturing. Biogases from the west sub-sag accumulated in the eastern drape structure and finally structural-lithologic gas pools are formed. The biogases in the Yangxin Sag were preserved because of good cap-rocks and a lack of faulting. The biogases in the Yangxin Sag were preserved because of good cap-rocks and a lack of faulting.

In shallow formation, anaerobic degradation of crude oil occurred frequently, it change the oil into heavy oil and generate Oil-degraded biogas, so that the oil-degraded biogas is accumulated near heavy oil pools (Zhu et al, 2005; 2007). In the biogas generation, water activity plays an important role for microorganism propagation. The biogas reserves are determined by the quantity of biodegraded oils. Shanjiasi Neogene biogas reservoir is located in the Binxian uplift. It is buried above less than 1000 m. The reserves of biogases are $16.5\times10^8 m^3$. It is a shallow-buried, low abundance and small gas field. The gases show the microorganism degradation characteristics. The sources of biogases are oil pools (reserves are 104.3 million ton) around the biogases. The oil pools are commonly degraded and most of the n-alkane in oil has been degraded by microorganisms. The Binxian uplifted structure location in the dip direction of the Lijin Sag, it is prior to the capture of oil and gas which generated by Es_4 source rock in Lijin Sag during N stage. Because of shallow buried, many oil pools stated in the bacterial activity zone, During this stage, almost all faults in shallow formation are active, Infiltration of surface water along these active faults and carry enough nutrients for microbial. Those microbial degraded oil and finally generates biogas. The faults not only provide good migration pathways for biogases and infiltration water when they are active, but also act as a good seal for the biogases when they are not active.

3. Distributions

Different genetic types biogases accumulated in different structural positions in Jiyang Depression. The rock-derived biogas mostly distributed in the shallow sag or slope (Fig.1). In these areas, immature hydrocarbon source rocks are developed which are material basis of source rock-derived biogas generation. For example, Yangxin Sag Es_1, Central Uplift of Dongxin and Gaoqing - Huagou slopes Es_1 biogas reservoirs.

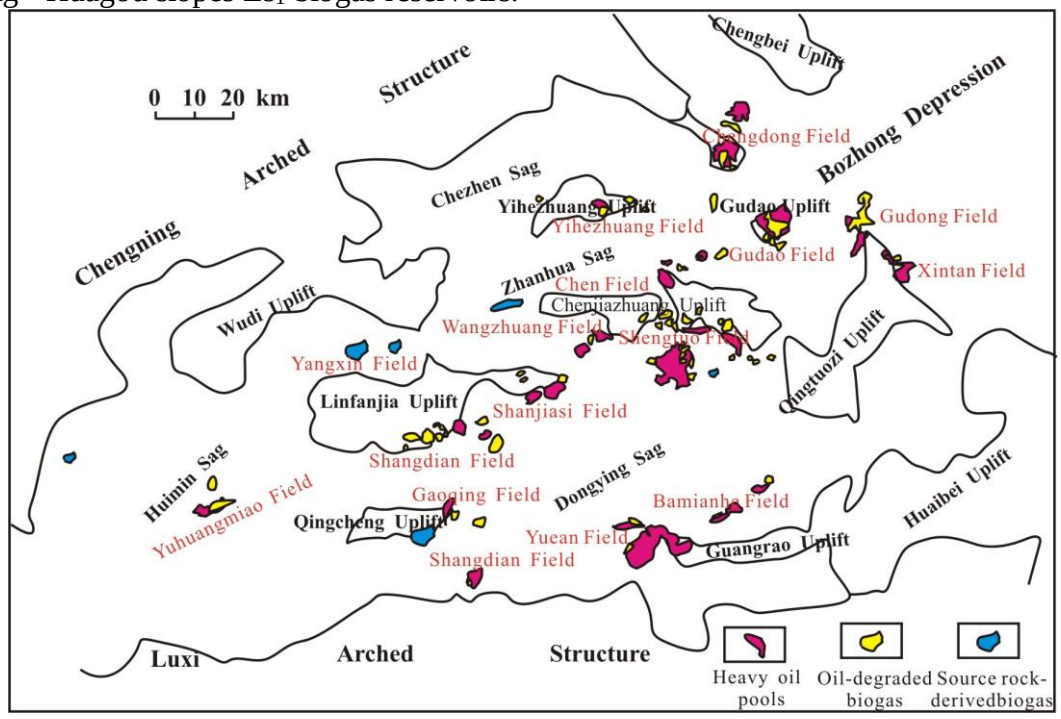

Figure 1. Distribution of heavy oil and different kinds of biogas in the Jiyang Depression

Oil-degraded biogas is distributed in a ring along with the depression, because most heavy oil reservoirs are distributed in these areas. For example, large number of heavy oil pools and oil-degraded biogas reservoirs distributed in Chenjiazhuang, Binxian and Qingtuozi uplift where around the Dongying Depression (Fig.1).

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