埕北古 7 潜山太古界油气藏流体类型识别

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摘要: 油气藏的流体类型是计算油气储量、选择开发方式、制定技术政策的关键,因此查清流体类型对油气藏开发具有重要的意义。以埕北古 7 潜山太古界为研究目标,依据埕北古 7 井流体组分分析结果和流体相态实验为基础,利用方框图法、C_2^+ 含量判别法、油气藏流体三元组成三角图法等经验统计方法和流体相态分析方法对埕北古 7 潜山的油气藏流体类型进行识别。结果表明,原始地层条件下,埕北古 7 潜山太古界油气藏流体呈油气两相状态,油气藏顶部为凝析气顶,底部为油环。结合地质研究成果可知,油环面积远大于凝析气顶面积,因此确定埕北古 7 潜山太古界油气藏类型为以油为主的凝析气顶油藏。

关键词: 油气藏类型 凝析气藏 气顶 油环 流体相态
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埕北古 7 潜山位于埕北低凸起的南部,埕北 30 断块西部,为断层控制的残丘山。埕北古 7 井完钻井深为 3 346 m,成像测井资料表明,潜山内部裂缝发育,以网状缝为主。2010 年 5 月埕北古 7 井在太古界(3 140.05 ~ 3 194.71 m)中途测试,6 mm 气嘴生产,产气量为 15 615 m^3/d,产油量为 5.72 t/d,生产气油比为 1 982 m^3/m^3,地面原油密度为 0.749 7 g/cm^3,地面原油粘度为 0.61 mPa·s;全井段(3 140.05 ~ 3 346 m)完井测试,8 mm 气嘴生产,产气量为 111 361 m^3/d,产油量为 99.9 t/d,生产气油比为 880 m^3/m^3,地面原油密度为 0.781 4 g/cm^3,地面原油粘度为 1.58 mPa·s。从 2 次测试的结果来看,埕北古 7 潜山流体类型比较复杂,生产气油比高,属于低密度、低粘度原油,2 次测试的生产气油比及流体性质差异较大[1],无法直接确定其油气藏流体类型[2-3],因此笔者利用经验统计法和相态分析法[4]对埕北古 7 潜山的油气藏流体类型进行了分析和研究,以期为该区块的有效动用提供依据。

1 流体取样及组成分析

流体类型的判别必须有准确可靠的数据[5-6],为了落实埕北古 7 井的油气藏流体类型,2011 年 6 月 22 日,在 8 mm 气嘴稳定生产时,进行地面分离器取样。取样的条件包括:层位为太古界;井段为 3 140.05 ~ 3 346 m;地层压力为 32.5 MPa;地层温度为 137.25 ℃;分离器温度为 15.6 ℃;分离器压力为 2.34 MPa;取样时产气量为 104 490 m^3/d,产油量为 91.2 t/d,油管压力为 17.5 MPa,套管压力为 4 MPa;分离器气油比为 1 145.7 m^3/m^3。

按照原始气油比将分离器取样的凝析油、天然气样品配制成油气藏流体样品,通过油、气组成色谱分析及井流物组成计算(表 1),得到井流物组成中 C_1 摩尔分数为74.04%,C_2—C_9 摩尔分数为20.01%,

表 1 埕北古 7 井井流物组成

组分	凝析油	天然气		井流物	
	摩尔分数,%	摩尔分数,%	质量浓度/(g·m^{-3})	摩尔分数,%	质量浓度/(g·m^{-3})
CO_2	0.37	1.68		1.51	
N_2	0.32	1.49		1.34	
C_1	9.73	83.49		74.04	
C_2	5.73	8.19	102.38	7.88	98.45
C_3	6.23	3.34	61.23	3.71	68.02
iC_4	2.14	0.52	12.56	0.73	17.57
nC_4	5.17	0.9	21.75	1.45	34.97
iC_5	2.78	0.16	4.8	0.5	14.87
nC_5	4.22	0.16	4.8	0.68	20.39
C_6	11.37	0.05	1.79	1.5	53.78
C_7	8.91	0.01	0.42	1.15	47.92
C_8	7.69			0.99	46.78
C_9	6.64			0.85	45.4
C_{10}	5.18			0.66	39.26
C_{11}^+	23.53			3.02	305.33

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C_{11}^{+}摩尔分数为3.02%。其中，C_{11}^{+}相对密度为0.871 5，相对分子质量为243.51；分离器气体的相对密度(空气相对密度为1.0)为0.657 3，凝析油在20 ℃密度为0.774 6 g/cm³。

2　流体类型识别

发现油气藏后，早期取得有代表性的油气藏流体样品和获得流体组成及物性分析资料，判别油气藏地下流体类型对于有效开发油气藏具有极其重要的作用。目前，油气藏流体类型的识别主要包括经验统计法和相态分析法2类方法，经验统计法一般只需要地面测试和流体取样分析数据，比较简单易行，相态分析法是基本的且可靠的方法，但必须取得有代表性的流体样品和精确的PVT实验数据[4]。

2.1　经验统计法

经验统计法是根据已知的大量油气藏地层流体组成及特征参数寻找不同类型油气藏的规律性，指导油气藏类型判别。

2.1.1　方框图和C_2^{+}含量判别法

根据埕北古7井井流物组成，按照不同类型油气藏方框图(图1)和C_2^{+}含量判别法分类标准[7]，埕北古7潜山太古界油气藏流体属于带油环凝析气藏或凝析气顶油藏。

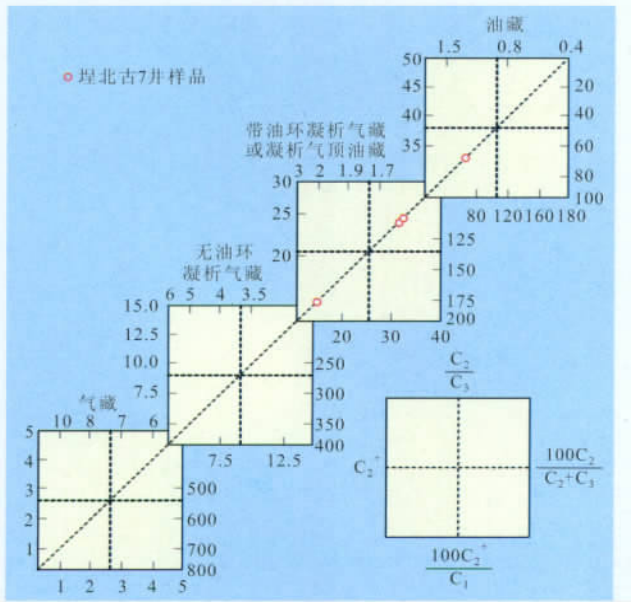

图1　不同类型油气藏方框图

2.1.2　ϕ_1参数判别法

利用ϕ_1参数判别法[7]，根据埕北古7井井流物组成计算得到ϕ_1值为11.89，按照ϕ_1参数的分类标准，埕北古7潜山太古界油气藏流体属于凝析气顶油藏。ϕ_1参数判别法根据102个油气藏检验，符合率为85%[7]。

2.1.3　油气藏流体三元组成三角图法

根据埕北古7井井流物组成，C_1和N_2摩尔分数为75.38%；C_7^{+}摩尔分数为6.68%；C_2—C_6和CO_2摩尔分数为17.96%。从埕北古7井油气藏流体三元组成(图2)可以看出，埕北古7潜山太古界油气藏流体属于凝析气藏。

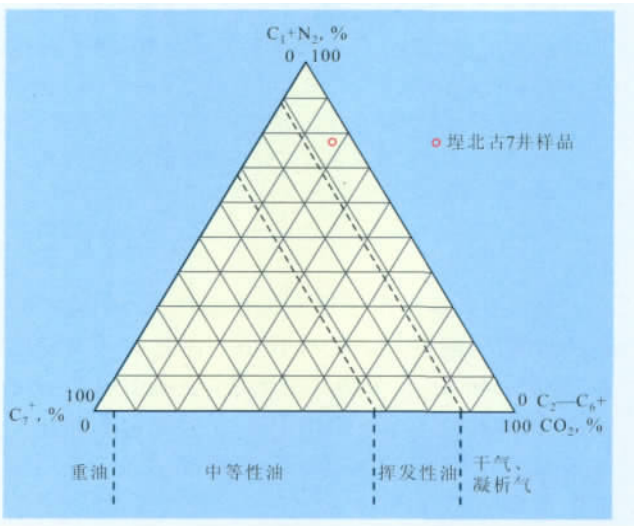

图2　埕北古7井油气藏流体三元组成

2.1.4　生产气油比与油罐油密度关系判别法

埕北古7井分离器气油比为1 145.7 m³/m³，油罐油在20 ℃密度为0.774 6 g/cm³。按照生产气油比和油罐油密度的分类标准，埕北古7潜山太古界油气藏流体属于挥发油和凝析油气过渡带。

2.1.5　凝析气藏是否带油环判别法

油气藏凝析气C_5^{+}和C_1/C_5^{+}值判别法　埕北古7井油气藏流体C_5^{+}摩尔分数为9.03%，C_1/C_5^{+}值为8.23，根据判别标准[7]，埕北古7潜山太古界油气藏流体属于带油环的凝析气藏。

等级分类判别法　根据埕北古7井流体组分组成计算4项特征参数：$F_1=C_1/C_5^{+}=8.23$，$F_2=(C_2+C_3+C_4)/C_5^{+}=1.52$，$F_3=C_2/C_3=2.13$，$F_4=C_5^{+}=9.03$；利用4项特征参数值求等级数之和[7]为14，按照等级分类判别法判别标准[7]，埕北古7潜山太古界油气藏流体属于带油环凝析气藏。该方法根据102个油气藏检验，符合率为91%[7]。

Z因子判别法　根据埕北古7井井流物组成计算，$F=(C_2+C_3+C_4)/C_5^{+}=1.52$；$Z_1=(0.88C_5^{+}0+99C_1/C_5^{+}+0.97C_2/C_3+0.99F)/3.71=5.30<17$；

$Z_2 = (0.79C_5^+ + 0.98C_1/C_5^+ + 0.95C_2/C_3 + 0.99F)/3.71 = 5.05 < 17$，按照 Z 因子判别法判别标准[7]，埕北古 7 潜山太古界油气藏流体属于带大油环的凝析气藏(或油藏)。

2.2　相态分析法

对配好的地层流体样品进行了 PVT 全分析实验。实验模拟地层温度为 137.25 ℃。根据实验室进行的流体相态特征测试(如露点压力测试)、等组成膨胀实验测试以及定容衰竭实验测试等，表明配制的地层流体呈现为凝析气特征(图 3)，露点压力为 41.70 MPa，高于原始地层压力 9.20 MPa，说明流体在原始地层条件下呈油气两相状态[4-10]，且埕北古7井在生产过程中油气同出，生产井段(3 140.05～3 346 m)存在油气界面。

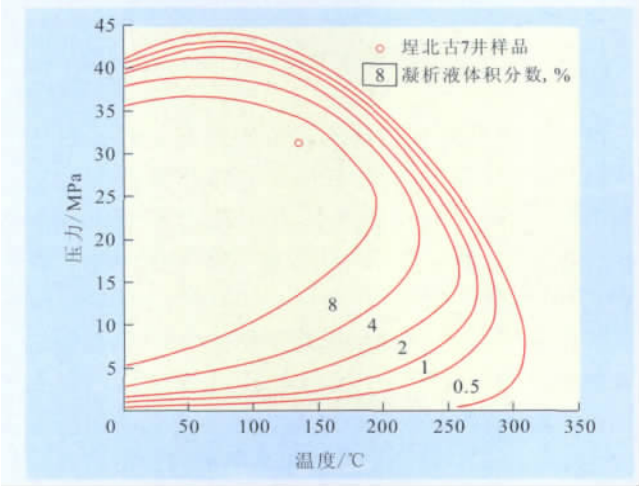

图 3　埕北古 7 井流体相分布

根据相态实验研究，原始地层条件下凝析气顶的气油比为 1 515.7 m^3/m^3，而中途测试的生产气油比(1 982 m^3/m^3)高于凝析气顶的气油比，说明中途测试井段(3 140.05～3 194.71 m)没有超出气顶范围，油气界面应该在 3 194.71 m 以下，因此，油气界面位于 3 194.71～3 346 m。

3　油气藏类型的确定

流体相态分析方法和多种经验统计方法的判别结果表明，埕北古 7 井太古界油气藏流体类型为带油环的凝析气藏，并且油环面积较大。

结合地质研究成果，埕北古 7 潜山含油气井段长，纵向上油气闭合高度为 564 m，其中埕北古 7 潜山凝析气顶的气柱高度为 54～206 m，油柱高度为 368～510 m，因此，埕北古 7 潜山太古界油气藏类型是以油为主的凝析气顶油藏(图 4)。

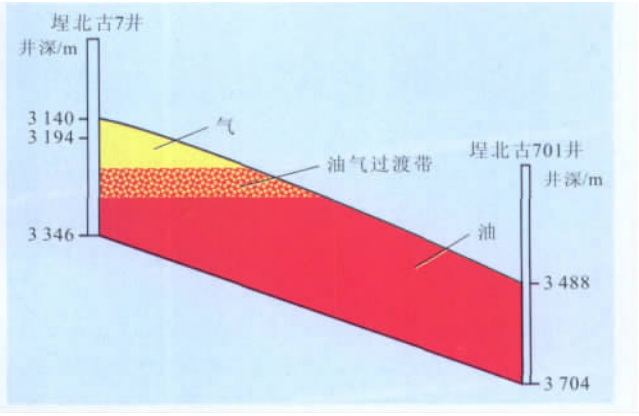

图 4　埕北古 7 井地下流体分布

4　结束语

埕北古 7 潜山太古界油气藏流体类型为以油为主的凝析气顶油藏；埕北古7潜山的气柱高度为54～206 m，油柱高度为368～510 m，油气界面位于 3 194.71～3 346 m。经验统计法与相态分析法的评判结果具有较好的一致性；油气藏类型和油气界面的确定为该块油气储量计算、选择合理的开发方式、制定合理的开发技术政策提供了必要的决策依据。

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Wang Miao, Liao Yuantao, Deng Dafei et al. Reservoir characters and controlling factors of member one of Dongying group in fracture belt 1, Nanpu depression. ***PGRE*****, 2012, 19(4): 14-17.**

Abstract: Reservoir properties of member one of Dongying group in fracture belt 1 in Nanpu depression are studied by analyzing the data of petrophysical characteristics, combined with thin-section petrography and scanning electron microscopic (SEM). And, it is considered that they are controlled by sedimentation and diagenesis. The main reservoir rock type of the study area is feldspar-lithic sandstone, and the main pore type is intergranular porosity. The controlling effect of sedimentation on reservoir is analyzed from two respects: sedimentation controls reservoir lithology characters; and the microfacies types on reservoir lithology characters. The control of sedimentation on reservoir lithology characters is the foundation. Different provenance, different sedimentary environments and sedimentation process determine different lithological characters, which decide directly the petrophysical characteristics of reservoir. The petrophysical properties of submersed channel, mouth bar and turbidite fan channel are the best sedimentary micro-facies which can be good reservoirs. Composite reverse rhythmic are identified in sedimentary micro-facies, and homogeneous rhythmic petrophysical mode is more proper to form favorable reservoirs. Diagenesis influence on reservoir properties is revealed in three aspects: compaction, cementation and dissolution. A large number of interparticle dissolution pores are generated by dissolution which effectively improves the reservoir petrography.

Key words: reservoir characters; controlling factors; sedimentation; diagenesis; member one of Dongying group; Nanpu depression

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Zhang Juan. Study on fault-sealing in Pinghu oil and gas field, Xihu depression. ***PGRE*****, 2012, 19(4): 18-20.**

Abstract: Exploration practice showed that fault-sealing controlled the hydrocarbon distribution in Pinghu oil and gas field of Xihu depression, while the corresponding research had not been carried out. According to the sand-mud docking relationship on both sides of faults and smear gouge ratio calculation, fault-sealing evaluation of the main five faults in research area were studied, and the fault-sealing history in the key hydrocarbon migration period was reconstructed by the technology of layer flatten. The research results showed that fault-sealing in Pinghu Formation was better, and in Huagang Formation was weaker, when smear gouge ratio was more than 68 percent, fault side blocking were formed. Fault-sealing ability was changed by the various tectonic evolutionary stages and had relationship with tectonic stress field: in the faulted stage, the research area was mainly in tensile stress, and the faults was open; in the depression stage, some regions was mainly in compression-torsion stress, and the faults in the area was seal such as number 1 fault and in the north of number zero fault, fault-sealing in the other regions was weak.

Key words: fault mud ratio; mudstone smear potential; tectonic stress field; fault-sealing; Pinghu oil and gas field

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Chang Jianfeng, Xu Yaodong, Tian Tonghui et al. Reservoir fluid type identification for Archaeozoic reservoir in Chengbeigu 7 buried hills. ***PGRE*****, 2012, 19(4): 21-23.**

Abstract: The identification of reservoir fluid types is key to the calculation of oil and gas reserves, optimization of the development way, and decision of the key technology policy. So how to make clear the underground fluid types is of vital significance for reservoir development. Based on the fluid component analysis result and fluid phase behavior experiment of the well flow, and using a variety of statistical methods and fluid phase analysis method, we identify the reservoir fluid type of the Chengbeigu 7 buried hills. The results show that the reservoir fluid type of the Chengbeigu 7 buried hills is represented as the oil gas two-phase state in the original formation conditions. Combined with geologic research results, the reservoir fluid types of Chengbeigu 7 buried hills is condensate gas cap reservoir.

Key words: *reservoir type*; *condensate reservoir*; *gas cap*; *oil ring*; *fluid phase*

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Zhang Jinwei, Yan Aiying, Liu Wenxiu et al. Study on reservoir occurrence rule in Cabiona block of Colombia. ***PGRE*****, 2012, 19(4): 24-26.**

Abstract: Colombia, the fourth largest oil&gas production country in South America, is abundant of petroleum deposits. Cabiona block is located in the forebulge slope of the foreland basin Llanos in Colombia, where is expected to be preferential for hydrocarbon migration and accumulation. By stratigraphic correlation combining with sequcence and tectonic research, the sedimentary facies of the target formation Carbonera have been defined as deltaic facies, including two subfacies of delta-front and prodelta. Four microfacies of submerged distributary channel, inter-distribuary area, mouth bar and sheet sand are identified. On the base of hydrocarbon migration and distribution and trap features, reservoir accumulation mode is built, which is discribed as multiple migration with far source, fault controlled reservoir distribution, structure controlled accumulation, and reservoir properties controlled oil enrichment. Four kinds of oil reservoir are summarized as anticlinal reservoir, lithology-faulted nose-like reservoir, lithology-fault reservoir and fault-lithological reservoir. The results of the research are expected to be used in guiding the E&P work in Cabiona block.