高邮凹陷北斜坡阜三段砂体展布及油气运移特征

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摘要:高邮凹陷北斜坡阜三段储层发育不均,油气运移路径复杂。通过细分砂层组,开展精细沉积微相研究,并结合大量油气显示资料综合分析了砂体展布及油气运移路径。结果表明,研究区阜三段各砂层组发育3—5支三角洲前缘水下分支河道,水下分支河道和河口坝微相砂体物性较好,其展布控制着优质储层的分布。油气运移路径在内、外坡带差异明显,在内坡带,油气运移受控于水下分支河道砂体的展布;在外坡带,油气运移则受构造和水下分支河道砂体的双重控制。因此,在内、外坡带须采取不同的勘探策略。

关键词:阜三段 砂体展布 油气显示 油气运移 高邮凹陷北斜坡
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运载层中的油气显示段肯定是发生过油气运移的通道空间[1],因此钻井油气显示资料是研究油气运移最直接的证据[2-5]。在钻井较密集的成熟区块,可充分利用油气显示资料解剖油气运移路径及其控制因素,以便指导新区及新层系的油气勘探。

高邮凹陷北斜坡整体表现为北抬南倾的斜坡,发育多个近南北向展布的宽缓鼻状构造带,与区内大量发育的近东西向和北东东向断层相匹配,形成一系列断鼻、断块群。由于断层发育、构造破碎,造成该区油藏具有含油断块多、面积小的特点。古近系阜三段(E_1f_3)是北斜坡的主要含油层系之一,勘探程度较高,积累了大量的钻井油气显示资料,为研究油气运移路径提供了基础。笔者整理了该区所有探井和评价井的油气显示资料,通过统计油气显示级别、油气显示砂岩厚度比和油气显示频度[6]综合确定油气运移路径,并结合砂体发育和构造特征研究控制油气运移的主要因素。

1 沉积微相类型及与储层物性的关系

高邮凹陷阜三段属于三角洲—湖泊沉积体系,物源来自于北东方向。斜坡主体为三角洲前缘亚相沉积,向南渐变为前三角洲亚相和湖泊相,发育水下分支河道、支流间湾、河口坝、远砂坝、席状砂和前三角洲泥等沉积微相,其中水下分支河道和河口坝是砂体发育的主要微相类型。

沉积微相影响岩石粒度和砂体厚度等[7-10],从而控制了储层物性。水下分支河道和河口坝微相砂体主要为细砂岩、细—中砂岩,在电测曲线反映的砂体厚度特征上,水下分支河道微相单层厚度较大,为3～9 m,河口坝微相单层厚度略小,为1.5～3.5 m,在不同深度段物性均较好(图1);而三角洲前缘席状砂及远砂坝微相砂岩大多为粉砂岩,部分为粉—细砂岩,单层厚度通常仅为0.5～2 m,储层物性偏差。

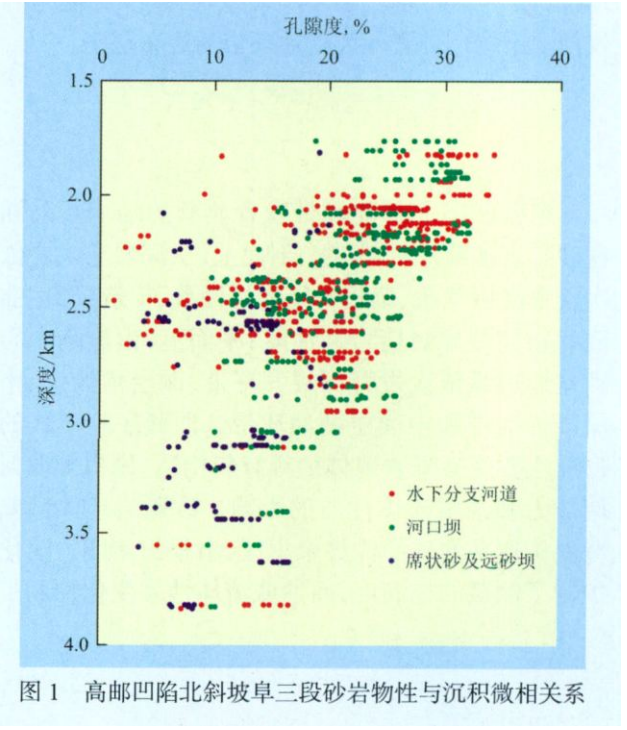

图1 高邮凹陷北斜坡阜三段砂岩物性与沉积微相关系

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2　砂体展布特征

研究区以亚段为单元的沉积微相研究开展较早，但随着勘探程度的不断提高，其预测精度难以满足勘探的需要。笔者在3个亚段划分的基础上，通过建立研究区典型井地层剖面并开展地层精细对比，按沉积旋回将E_1f_3进一步细分为$E_1f_3^{3-1}$，$E_1f_3^{3-2}$，$E_1f_3^{3-3}$，$E_1f_3^{2-1}$，$E_1f_3^{2-2}$，$E_1f_3^{2-3}$，$E_1f_3^{2-4}$，$E_1f_3^{1-1}$，$E_1f_3^{1-2}$和$E_1f_3^{1-3}$共10个砂层组，并编制了各砂层组的砂岩厚度、砂地比、沉积微相等图件，精细刻画砂体展布特征。

在阜三段沉积时期来自于北东方向的物源较为稳定，在北斜坡主体沙花瓦地区形成3—5支三角洲前缘水下分支河道，同时由于北斜坡较为平缓，造成各水下分支河道频繁摆动，各砂层组水下分支河道形态各异。以$E_1f_3^{1-1}$砂层组为例，该砂层组厚度为20~35 m，发育5支呈条带状展布的水下分支河道，其长度约为10~25 km，宽度约为3~8 km。

3　油气显示及油气运移特征

高邮凹陷北斜坡阜三段油气来自下伏的阜二段烃源岩，其油气通过断层、辉绿岩变质带等向上运移进入阜三段储层，受斜坡构造的控制，油气运移总体表现为沿单斜地层砂体—断裂阶梯状侧向长距离运移输导模式。

纵向上，受砂地比、储层物性、油气运移路径等多种因素的影响，内、外坡带的油气运移具有差异性。统计结果表明：在南部内坡带，油气显示井段较长，可达250 m；在北部外坡带，油气显示井段逐渐向上部地层集中，一般不超过120 m。

总体来说，10个砂层组中位于中上部的$E_1f_3^{1-1}$，$E_1f_3^{1-2}$，$E_1f_3^{1-3}$和$E_1f_3^{2-1}$油气显示较为活跃，尤以顶部的$E_1f_3^{1-1}$最为活跃，其油气显示砂岩厚度占总砂岩厚度的69.2%，油气显示砂岩层数占总砂岩层数（即油气显示频度）的88.3%（图2）。

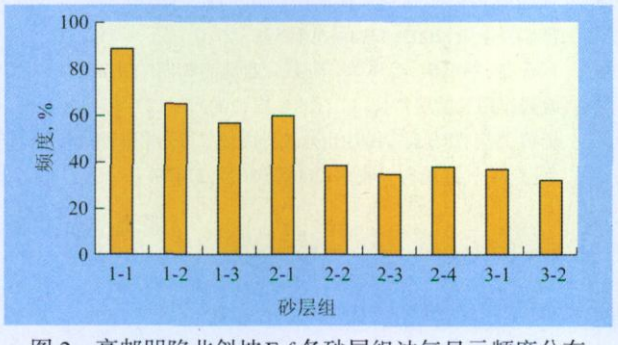

图2　高邮凹陷北斜坡E_1f_3各砂层组油气显示频度分布

从$E_1f_3^{1-1}$砂层组各井油气显示级别、显示频度与砂地比和构造的关系研究可以发现，油气显示受砂体展布、构造等因素影响，内、外坡带也具有明显的差异。

在内坡带（沙19—苏141—花14井一线以南），砂地比一般小于0.3，油气显示频度与油气显示级别主要受控于砂体发育情况，如位于东部水下分支河道上的花21、花X17、花X22、东62等井油气显示达到油斑级别（图3），油气显示频度均为100%（图4）；位于水下分支河道侧缘和支流间湾的花23、花X25等井，油气显示级别只有荧光—油迹，油气显示频度也明显变低，为33%~50%，花深X1等井更无油气显示。这表明，在内坡带油气运移主要集中于物性条件较好的水下分支河道砂体，油气运移路径与水下分支河道展布密切相关。

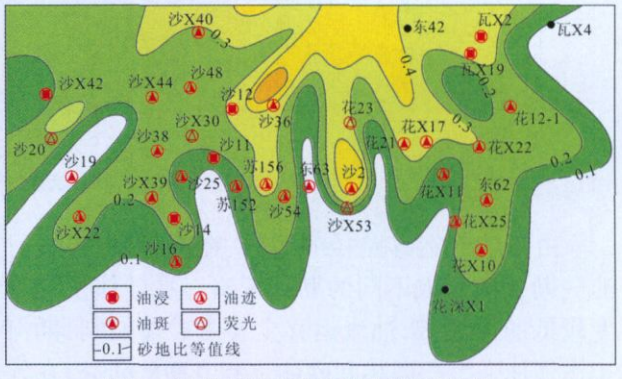

图3　沙花瓦地区$E_1f_3^{1-1}$砂层组油气显示级别与砂地比叠合

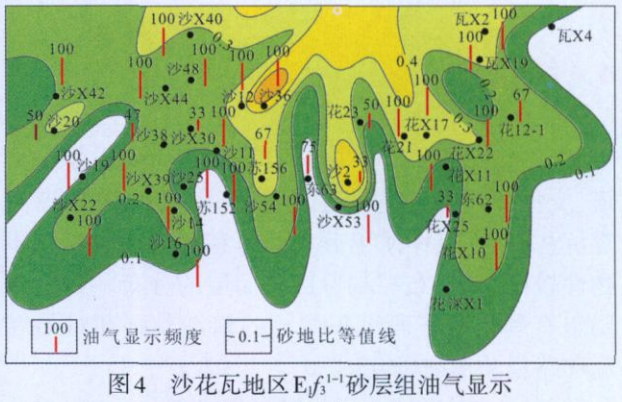

图4　沙花瓦地区$E_1f_3^{1-1}$砂层组油气显示频度与砂地比叠合

在外坡带（沙19—苏141—花14井一线以北），砂地比一般大于0.3，油气显示频度及油气显示级别不仅受砂体控制，受构造控制也愈加明显。同样以东部的沙花瓦地区为例，既位于水下分支河道主体又处于构造圈闭内的瓦X2和瓦X19等井油气显示最高级别为油浸，油气显示频度为100%；同样位于水下分支河道主体但未处于构造圈闭内的东42等

井则无油气显示；处于构造圈闭内但位于水下分支河道侧缘或支流间湾的瓦X4、瓦X18等井也无油气显示（图5），表明在外坡带，由于砂体发育程度高，砂体间连通性增强，油气显示频度及油气显示级别受砂体控制作用减弱，受构造的控制作用明显增强，油气运移受构造和砂体双重控制。

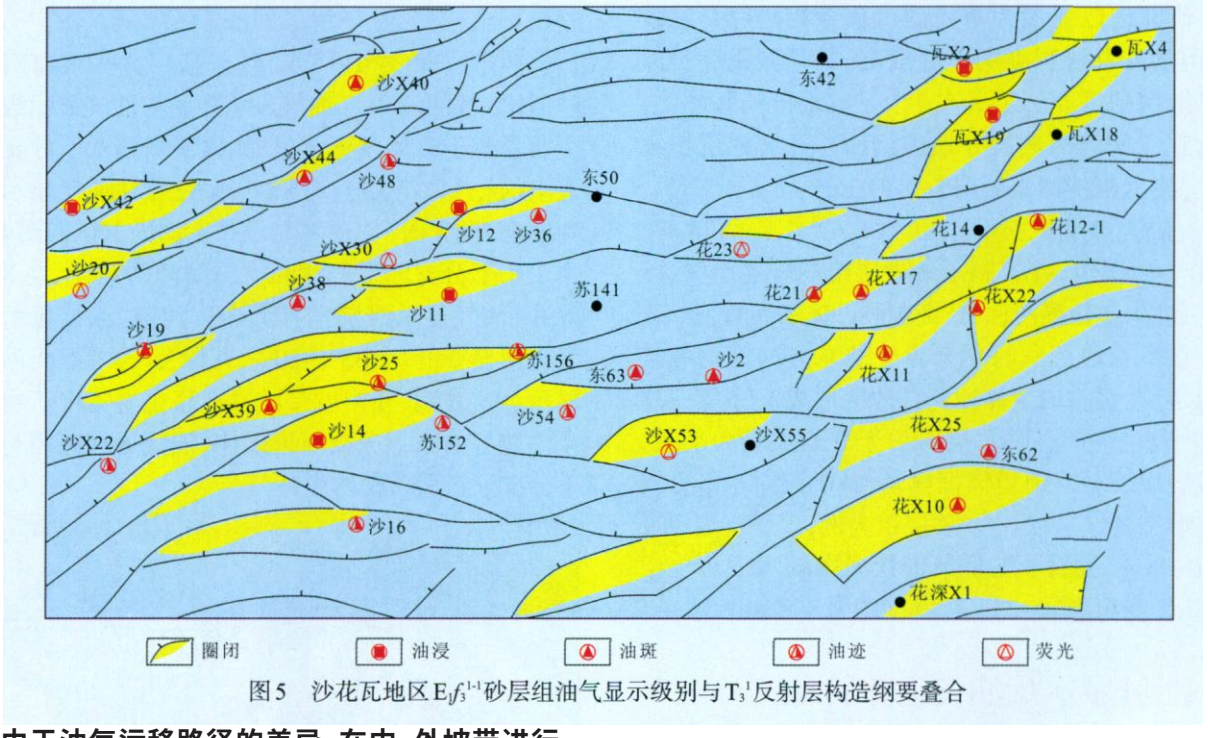

图5　沙花瓦地区$E_2f_3^{1-1}$砂层组油气显示级别与T_3^1反射层构造纲要叠合

由于油气运移路径的差异，在内、外坡带进行油气勘探须采取不同的勘探策略。在砂体发育程度较低的内坡带，油气运移主要受砂体控制，勘探工作须加强沉积微相和砂体预测方面的研究；在外坡带，砂岩发育程度高，油气运移受构造控制作用增强，须重点加强构造圈闭的描述工作。

4　结论

高邮凹陷北斜坡主体阜三段发育水下分支河道、支流间湾、河口坝、远砂坝、席状砂、前三角洲泥等沉积微相，其中水下分支河道和河口坝微相砂体物性较好，其展布控制着优质储层的分布。细分砂层组有利于阜三段沉积微相的精细刻画和对油气运移路径的精细研究。

通过对大量钻井油气显示统计分析表明，高邮凹陷北斜坡内、外坡带油气运移路径差异明显：在内坡带，油气运移路径受控于三角洲前缘水下分支河道砂体展布；在外坡带，油气运移路径受构造和砂体的双重控制。在内、外坡带须采取不同的勘探策略。

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编辑　经雅丽

Abstract:Martaban Basin located in Andaman Sea, is a typical back-arc strike slip and extension basin. The tectonic evolution of Martaban Basin is closely related with the oblique convergence of the Indian beneath the Myanmar plates. Its depocenter is controlled by the Mergui and Sagaing strike-slip faults and the main sources are from the Irrawaddy River in the north and Salween River in the northeast respectively. From the analysis of characteristics of petroleum geology, the Martaban Basin comprises two mature hydrocarbon source rocks and one biological gas source rock. The Middle Miocene hemipelagic shales overlie the Oligocene-Lower Miocene reef limestones and shallow marine sandstones, which comprise good reservoir-seal assemblages. The Pliocene-Pleistocene delta front sandstones interbedded with shales are the main pays of shallow biogas. The trap types are mainly faulted-anticlines, faulted blocks, reef traps and structural-stratigraphic combined traps. Faults and unconformities are the favorable migration pathways. Future exploration should typically be oriented at faulted blocks and horst in the center area of basin for the shallow biogas, and the western volcanic uplifts, central inherited uplifts and structural terraces in eastern ramp region for the thermogenic gas respectively.

Key words:back-arc strike slip and extension basin; petroleum geology feature; exploration direction; Martaban Basin; Andaman Sea

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Liu Xinjin, Song Guoqi, Liu Huimin et al. Study of conglomerate reservoir types and distribution in north slope zone, Dongying depression. *PGRE*, 2012, 19(5): 20-23.

Abstract:There are several conglomerate reservoir types in the eastern north steep slope zone in Dongying depression, whose distribution has an ordered sequence. By the dissection of different conglomerate traps, the basic characteristics of these reservoirs and controlling factors of their ordered distribution are discussed. On the basis of reservoir characteristic and distribution law, the ordered reservoir combination pattern includes under-salt condensate gas reservoir, fan root lithologic reservoir, structural-lithological reservoir, and the digenesis trap reservoir that is sealed by difference of physical properties. The reservoir series, that are in order of under-salt gas play, deep zone thin oil play, medium-deep thin oil play, and shallow layer heavy oil play, are distributed ring-shaped around the subsidence centre of the basin. Every reservoir type had its particular hydrocarbon accumulation controlling factors. The main pool controlling factors of deep condensate gas and thin oil lithologic reservoir are the sealing capacity of fan root, the one for medium-deep structural-lithologic reservoir is development of small anticlinal traps, and the heavy oil is thick, which is the key controlling factors for shallow layer reservoir that is sealed by difference of physical properties. Different exploration plans are designed according to the reservoir characters and oil distribution law.

Key words:conglomerate; reservoir types; evolutionary series; controlling factor; Dongying sag

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Liu Qidong. Sand-body distribution of the E_1f_3 member and its relationship with hydrocarbon migration in the northern slope of Gaoyou sag. *PGRE*, 2012, 19(5): 24-26.

Abstract:The E_1f_3 member is featured by serious reservoir heterogeneity and complex hydrocarbon migration pathways. Based on the study of sedimentary microfacies and stratigraphic correlation of the sand sets, we analyze comprehensively the hydrocarbon migration pathway by integrating oil and gas show of drilling data in this paper. The result indicates that there are 3-5 subaqueous distributary channels in every sand subset in the north slope of Gaoyou sag, and the study shows that the subaqueous distributary channel and channel-mouth bar are more available for the reservoir property, and its sand-body distribution controls the spread of the high quality reservoir. Further analysis reveals that the hydrocarbon migration pathways are different between the inner and the outer slope. In the inner slope, the hydrocarbon migration pathways are influenced by the distribution of subaqueous distributary channel, and in the outer slope, the hydrocarbon migration pathways are controlled by both the tectonic zone and the sand-body distribution. So, different prospecting tactics in the inner and the outer slope should be considered.

Key words:E_1f_3 member; sand-body distribution; oil and gas show; hydrocarbon migration; north slope of Gaoyou sag

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Zhang Xintao, Niu Chengmin, Huang Jiangbo et al. Hydrocarbon migration of Bozhong34 in Lower Minghuazhen Formation, Huanghekou sag, offshore Bohai sea. *PGRE*, 2012, 19(5): 27-30.

Abstract:The characteristics of migration system and its relationship with the distribution of middle shallow hydrocarbon reservoir in the Bozhong34 block of the Huanghekou sag in the offshore Bohai Bay Basin show that, the faults and sandbodies dominate the hydrocarbon migration system in the block. The distribution of sandbodies and faults are not the only factor that controls hydrocarbon enrichment in the study area. The spatial and temporal configurations of faults and sandbodies also control the effectiveness of migration system, thus determine the formation and occurrence of the oil reservoirs in the middle shallow layers. Through the static model of faults and sandbodies, the contact area of faults and sandbodies is important parameter controlling oil-gas filling degree, reserves abundance, and oil column height. Moreover, it guides the well position of Bozhong34-B and reservoir prediction. Quantitative study about configurations of faults and sandbodies with petroleum accumulation model has important value in theory and field application for expanding exploration space and locating the potential reservoir.

Key words:faults; migration system; configurations of faults and sandbodies; hydrocarbon migration; Huanghekou sag

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