孤岛油田中一区聚合物驱油井见效特征及影响因素

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前 言

聚合物驱油是三次采油技术中比较成熟的方法。在适当条件下，聚合物驱能够取得明显的降水增油效果，但注聚区内油井单井见效程度差别较大，见效规律各异，这主要是由储集层性质、局部剩余油饱和度及注采关系等多方面因素影响而造成的。本文研究了孤岛油田中一区馆 3 层系聚合物驱油井变化特点，进行了合理分类，分析了相应的影响因素，为其它聚合物驱的开发管理提供借鉴。

试验开展情况

孤岛油田为披覆构造油气藏，油层为高渗透的河流相正韵律沉积，原油黏度高。中一区馆 3 聚合物驱试验区位于孤岛油田主体部位的顶部，含油面积为5.1 km^2，有效厚度 12.5m，地质储量 1243×10^4t，层系为馆 3 砂层组，注聚区包括先导试验区和扩大试验区。馆 3 层系构造平缓，南高北低，岩性以粉细砂岩为主，孔隙度 33%，空气渗透率 1.5～2.5μm^2，泥质胶结为主，泥质含量9.5%～15.0%，胶结疏松，油井出砂严重，油层渗透率变异系数为0.54，地下原油黏度为46.3mPa·s，油层水矿化度 5000～6000mg/L，油层温度 67℃。中一区馆 3 层系 1971 年 9 月投入开发，1974 年 9 月以 270m×300m 的反九点注水方式投入注水开发，1983 年 10 月调整为 270m×300m 的行列注采井网，至注聚合物前（1992 年 8 月）中一区馆 3 层系综合含水为 90.1%，采出程度31.4%。

中一区馆 3 注聚先导试验区由 4 个五点法注采井组组成（注入井 4 口，采油井 11 口，中心井 1 口）。先导试验自 1992 年 9 月开始，1997 年 3 月转入后续水驱。共注入聚合物溶液 0.29 倍孔隙体积，注入液量 $80.5\times10^4m^3$。聚合物驱扩大试验区位于先导区周围，包括注入井 40 口，生产井 75 口（其中中心井 40 口，边角井 35 口）。扩大试验自 1994 年 12 月开始，1997 年 3 月转入后续水驱，共注入聚合物溶液 0.27 倍孔隙体积，注入液量 $502.9\times10^4m^3$。

先导试验区注聚合物 11month 以后，油井陆续见到效果，日产油量上升，含水下降。截止到 1999 年底，见效井 11 口，见效率 100%，试验区累计增油 16.7×10^4t，提高采收率 10.14%，每吨聚合物已增油 120.1t。在中心井中，中 11J11 井综合含水由注聚前的 91.5% 下降到最低点（49.9%），下降幅度大。

同先导试验区一样，扩大试验区注聚合物 11month 后油井开始见效，截止到 1999 年底，见效井 73 口，见效率 97.3%，扩大试验区累计增油 63.4×10^4t，提高采收率 5.88%，每吨聚合物增油 73.6t。

油井见效特征及影响因素

注聚后，注聚区的综合含水变化呈漏斗形状，但单井变化较复杂，研究注聚区可对比油井 65 口，其含水变化出现了"U"字型、"V"字型、"W"字型和不见效型 4 种类型，各类型见效特征不同（见表 1），影响因素也不同。

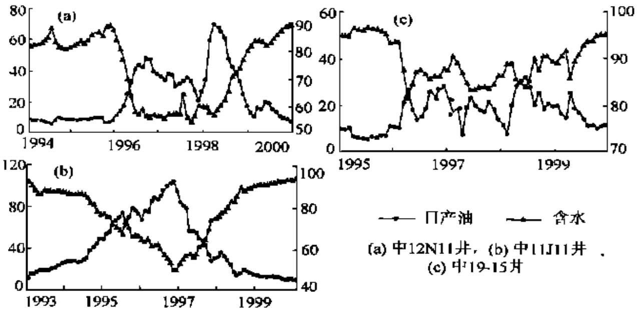
表 1 油井含水变化类型特征表

项 目	"U"字型	"V"字型	"W"字型	不见效井
井数（口）	4	30	29	2
占对比井比例（%）	6.2	46.2	44.6	3.1
开始见效时间（month）	15	16	13	
含水下降至最低值时间（month）	26	28	21	
含水开始回返时间（month）	50	29	47	
含水下降最大幅度（%）	36	15	12	
平均单井增油（10^4t）	3.7	0.82	0.85	

1 "U"字型含水变化油井

"U"字型油井见效时间长、含水下降幅度大，累计增油量高，见聚较晚，4 口井平均单井累计增油量已达 3.7×10^4t，是"V"和"W"型油井单井累计增油的4.5 倍，30month 开始见聚，48month 见聚浓度达到峰值，峰值浓度平均为 224mg/L。先见效后见聚说明，聚合物驱有效地扩大了波及体积。

该类油井主要集中在试验区中部，属于中心井，单层生产，油层厚度一般为 8～10m，井组渗透率变异系数较小，平均为 0.5，在适合聚合物驱的最佳范围(0.5～0.8)之间，剩余油饱和度较高(平均 50%以上)，注采关系稳定。层间及平面上油层较均质，注采稳定，保证了注聚段塞多向均匀推进，在段塞前缘形成较长原油富集带，使得油井能够多向同时见效，其底部持续的时间取决于剩余油饱和度及油井与水井间的距离，剩余油饱和度越高、油井与水井间的距离越大，控制的剩余储量就越多，含水下降幅度及底部持续时间就越长，增油效果越好。如中 12N11 井是一口中心井，单采馆 3^5 层，油层厚度 9.6m，该井区渗透率变异系数为 0.38，剩余油饱和度为 48%，对应的注聚井注入稳定，中 12N11 井注聚后含水变化呈“U”字形(见图 1a)，累计增油达 3.88×10^4t。



横坐标为年份；左纵坐标为日产油量(t)，右纵坐标为含水(%)

图 1 时间与含水、日产油量关系图

2 “V”字型含水变化油井

“V”字型油井以中心井为主，边角井次之，中心井 23 口，占 77%，边角井占 23%。油层较厚，厚度平均为 14m，井组渗透率变异系数较大，平均为 0.7，也在适合聚合物驱的最佳范围，注采关系稳定。层间及平面上油层均质性差，多存在渗透率较高的小层或方向，聚合物段塞易沿渗透率较高的小层或方向往油井“指进”，使得油井在某一层位、某一方向首先见效，含水小幅度下降，随着注聚量的增加，其它层位、注聚方向陆续见效，油井含水继续下降，含水下降的幅度取决于剩余油饱和度高低。如中 11J11 井是先导区中心井，采馆 3^{3+4+5}层，油层厚度 22.5m，该井区渗透率变异系数为 0.75，对应的注聚井注入稳定，中 11J11 井注聚后含水变化呈“V”字形(见图 1b)，该井组注聚较早，剩余油饱和度较高，达到 52%，含水下降幅度大，见效时间长，增油效果好，累计注聚增油达到 8.2×10^4t。

注聚前对注水压力低、厚度大、非均质强的注聚井调剖，封堵大孔道，防止聚合物溶液沿大孔道突进，扩大波及体积，可使部分“V”字型油井向“U”字型油井转化，或延长“V”字型油井见效时间。

3 “W”字型含水变化油井

“W”字型油井主要是边角井，中心井次之，边角井 22 口，占 76%，中心井占 24%。该类井中，中心井的影响因素与“V”字型油井基本一致，不同的影响因素是注采关系稳定程度，“W”型中心井注采关系不稳定，造成平面各方向聚合物段塞推进速度差异大，形成多个“V”字型叠加，引起含水呈“W”型变化。边角井主要是由于水驱和聚合物驱的注入剂推进速度不一样，压力场变化较大，注水干扰强烈，引起含水呈“W”型变化。如中 19-15 井(见图 1c)，该井是一口边井，对应两口注聚井和两口注水井，注聚见效过程中，注入水推进较快，对中 19-15 井见效干扰较大，先后 3 次对外围水井降水降压，平衡压力场，确保了该井注聚效果，如 1996 年 4 月至 1997 年 1 月中 19-15 井见效后含水上升，1997 年 2 月将外围两口注水井注水量由 $440m^3/d$ 下降到 $210m^3/d$，中 19-15 井含水即由 90.6%下降到 83.5%，稳定了 7month。

4 不见效油井

65 口可对比井中，只有 2 口井效果较差。该类型井是边角井，含水变化平稳，没有出现明显的见效期。不见效的影响因素主要是水驱干扰大，抑制了聚合物驱效果。

结　论

1，注聚区内油井单井见效规律不一致，按含水变化，基本分为 4 类，主要影响因素是储集层非均质性、注采关系、剩余油饱和度。

2，研究注聚影响因素，提前采取措施，可以克服一些不利影响因素，有利于提高注聚合物效果。

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孤岛油田零散低品位储量开发实践与认识[刊]/毕秋军,宋书君...石油勘探与开发.-2000,27(7).-60～62

孤岛馆1+2砂层组零散分布于整个孤岛油田,是该油田岩性-构造复合油藏的产层。在依靠天然能量的常规试采方式下,影响该砂层组开采效果的主要因素有:油层多而薄、储量分散、油砂体小;天然能量弱,单井产能较低;成岩作用差,泥质含量高,水敏性强,导致油层在开采过程中出砂严重,加上出砂粒度较细,防治难度大。为了获得该砂层组较高的采收率,开辟了中30-8先导性注水开发试验区,优选了馆1+2油藏注水高效开发配套技术。经推广应用,使馆1+2油层的采收率由注水开发前的4.2%增加到目前的16.3%,实现了分布零散、薄层、出砂严重低品位油藏的高效开发。参2(毕秋军摘)

主题词 孤岛油田 注水 采收率 油藏描述 防砂 采油速度 注采系统

TE357.431 20000626

孤岛油田中一区聚合物驱油井见效特征及影响因素[刊]/蔡燕杰,赵金亮... //石油勘探与开发.-2000,27(6).-63～64

孤岛油田进行了聚合物驱试验,取得了明显的降水增油效果,注聚区内油井单井见效特点不同,按单井含水的变化划分为4种类型:“U”字型,单层生产,油层厚度较薄,含油饱和度高,具有含水下降幅度较大、见效时间长、累计增油量高、见聚较晚等特点;“V”字型井,多出现在油层厚度大,油层层内、层间非均质性强的区域,其含水下降幅度较小,见聚早,且大多见效同时见聚;“W”字型井,多为边角井,注采关系不稳定,含水下降幅度小,增油量较差;不见效型,受水驱干扰大,未见增油降水效果。每种类型的影响因素不同,主要影响因素是储集层性质、剩余油饱和度、注采关系等。图1表1参2(蔡燕杰摘)

主题词 油井 聚合物驱 效果 影响 因素

TE343 20000627

文南油田文79断块沙二下亚段沉积微相与开发效果分析[刊]/侯加根 //石油勘探与开发.-2000,27(6).-65～67

以沉积旋回研究为主,辅之厚度法、等高程法、多井闭合法等,在进行时间单元划分和对比的基础上,分析了沉积微相和砂体的展布。指出沙二下亚段是以水下三角洲平原的水下分流河道为骨架,控制了主力油层的发育和分布,储集层性质明显受沉积微相控制。以沉积微相为主线,查明了储量动用状况和油田水淹规律,指出沙二下亚段各生产层储量动用程度不均,水下分流河道微相储量最大、动用最好,分流次河道微相次之,天然堤和决口扇微相虽有一定的储量,但在目前技术状况下基本没有被水驱动用。调查表明,下一步动用储量潜力区仍然在水下分流河道和水下分流次河道微相带。图1表1参2(侯加根摘)

主题词 三角洲 沉积微相 砂岩体 水驱 开发效果 剩余油 文留油田

TE112.23 TE319 20000628

随机建模技术在孤岛油田西区精细油藏描述中的应用[刊]/孙国,张兴平... //石油勘探与开发.-2000,27(6).-68～69

精细油藏描述关键在于建立能够定量描述和表征油藏储集层及流体的油藏地质模型。孤岛油田西区馆陶组油藏属于河流相沉积,砂体分布零散,横向变化大,建立准确地质模型难度较大。应用先进的随机地质建模技术,确定了孔隙度、渗透率、含油饱和度的三维变异函数,优选指数模拟为最佳建模方法,建立了该区储集层参数三维地质模型,较好反映了储集层参数空间变化的非均质性。通过研究,主要有以下认识:①随机模拟的基础是求准变异函数,求准变异函数不但能直接评价储集层的非均质性,而且其准确程度直接影响模拟结果的精度;②强调地质约束,必须在充分认识地质规律的基础上,经过多种方法校验,选择合适的地质模型;③由于随机模拟方法本身的特殊性和地质条件的差异性,目前较成功的方法和实例往往只用于特定储集层,因此模拟难度较大,必须不断探索,总结经验;④只有把随机模拟技术应用到从勘探到开发的全过程中,并且与油藏数值模拟技术充分结合起来,其优越性才能充分发挥。图2参2(孙国摘)

主题词 随机建模 油藏描述 变异函数 地质模型

·综合·

P631.445 TE112.3 20000629

胜利油田胜海地区馆陶组上段油气藏勘探中的地震方

depression of Qaidam basin, and $N_1-N_2^1$ oil reservoirs exist in lower Youshashan Formation of Pliocene and Upper Ganchaigou Formation of Miocene whose oil-bearing intervals reach up to 1200 meters. The study area is characterized by different sedimentary facies, fewer correlation marker beds, two crossing reverse faults, long drilling and completion span, great changes of bushing elevations and heights above sea level, which results in the current different oil-water contacts determination in the same oil sand body and complicated strata correlation, and the oil sand body distribution and structural relief still remain unclear. This paper combines fine strata correlation with 3D geological model to comprehensively study the $N_1-N_2^1$ reservoirs to further determine faulting system, structural shapes, oil sand body distribution and oil reservoir type and its controlling factors. All the above mentioned provided a reliable reservoir model for program adjustment, and predicting favorable oil-bearing blocks. As a result oil-bearing area of 1.0 square kilometers was increased and oil in place of 110×10^4t was proved. **Subject heading**: High pracision, Stratigraphic correlation, Computer application, Reservoir type, Tap production potential, Gaskule oil field

A special lenticular "oil in water" lithologic reservoir. XING Zheng-yan; et al. (Geological Research Institute, Shengli Petroleum Administration, Shandong 257015, P. R. China). *Shiyou Kantan Yu Kaifa*. 27(6), 58-59. A lenticular oil-in-water reservoir is a type of reservoir that occurs commonly in a strong heterogeneous area. The main reasons for this are that the lithology changes in the process of deposition and that the petrophysical properties vary after diagenesis. During the process of petroleum migration, the water exists in the large pore throat and good permeable biogenic limestone is easily displaced due to capillary forces, thus, oil-bed is formed; while, water-bed is formed in the small pore throat and low permeable biogenic limestone for water is difficult to displace. As for this type of reservoir, oil-bed or water-bed is determined by the combination of fine stratigraphic correlation, coring data, geological logging data, oil test, pilot production, and electric log data. In order to develop the difficult producing reserves, interval of big thickness and good petrophysical properties should be taken into consideration preferably in the process of perforation, but the interval of poor petrophysical properties should be avoided. **Subject heading**: oil in water, Lithologic reservoir, Reservoir, heterogeneity, Shengli oil field

Practice and knowledge on sporadic low-grade reserve development of Gudao oil field. BI Qiu-jun (Shengli Petroleum Administration, Shandong, 257231, P. R. China). *Shiyou Kantan Yu Kaifa* 2000, 27(6), 60-62. The Member Ng1+2 of Guantao Formation in Gudao oil field is the type of fluvial abandoned channel and flood plain deposit, where the oil-bearing bed is abound and thin, the reserves is disperse, the oil reservoir is small and closed, the natural energy is weak, the productivity of single well is low, the diagenesis is unconspicuous, the shale content is high and the water-sensitive is obvious, all these result in serious sanding in exploitation and difficulties in control. Production wells in this zone exhibit the phenomena called "three lows one more" (low rate of oil production, fluid rate and fluid levels of wells and more shut-down wells) under conventional production test relying on natural energy. In order to get a higher oil recovery factor from this zone, based on researches on oil reservoir and properties of petroleum and synthetical proof, a pilot test area of waterflooding development called Zhong 30-8 was established in 1991, thereby technology from waterflooding development of Member Ng1+2 was formed. After this technology is spread, the recovery factor increases from 4.2% to 16.3%, and efficient development of sporadic, thin and serious sanding reservoir is realized. **Subject heading**: Gudao oil field, Water flooding, Recovery factor, Oil reservoir description, Sand control, Oil recovery rate, Injection-production system

The response and effecting factors of polymer flooding in Unit 1 of Central Gudao oil field. CAI Yan-jie; et al. (Shengli Petroleum Administration, Shandong, 257231, P. R. China). *Shiyou Kantan Yu Kaifa* 2000, 27(6), 63-64. The effect of decreasing water cut and increasing oil production is obtained by polymer flooding test in Gudao oil field. There are four kinds of response of oil wells in polymer flooding area with different water cuts of single wells. The first is a well with water cut curve of "U" type, which is producing oil from a single thin oil-bearing formation with high oil saturation, decreasing water cut by a big margin, long-term effecting and increasing high production. The second is a "U" type well which has a thick oil-bearing formation with strong heterogeneity in inner or inter-bed and decreases water cut by a small margin. The third is a "W" type well, which is located at the edge of injection area, with non-balanced injection and production, and decreases water cut by a small scale, but increases production little. The fourth is an invalid well which is disturbed by water flooding with no effect of increasing production. Factors effecting every type well are different, which are reservoir property, remaining oil saturation, relation of injection and production, and so on. **Subject heading:** Oil well, Polymer flooding, Effect, Influence, Factors

An analysis of sedimentary microfacies and production response for the lower part of the second shahejie sub-member in Block Wen-79 in the south of Wenliu oil field. HOU Jia-gen (University of Petroleum, Shandong 257062, P. R. China). *Shiyou Kantan Yu Kaifa* 2000, 27 (6), 65-67. Sedimentary time units are correlated by using sedimentary cycle, isopach, isometry and multi-well closed methods in this paper. After analyzing sedimentary microfacies and sandbody distribution, it is suggested that subaqueous distributary channel of subaqueous delta plain is the framework of the lower part of the second Shahejie sub-member. The main oil-bearing formation and its distribution are controlled by this microfacies. Reservoir petrophysical property is also controlled by sedimentary microfacies. By means of sedimentary microfacies distribution, we got a clear understanding about the reserve percentage developed and watered out law of oil field. The results show that there is no uniform reserve percentage developed in all production units, the subaqueous distributary channel with largest reserves is best water flooded, the distributary sub-channel is well water flooded, levee and crevasse splay deposits are poorly water flooded. The potential production areas are still the subaqueous channel and the subaqueous distributary sub-channel. **Subject heading:** Delta, Sedimentary microfacies, Sard body, Water drive. Development effectiveness, Remaining oil, Wenliu oil field

The application of random modeling technology in fine reservoir description of the west area of Gudao oil field. SUN Guo; et al. (Geologic Research Institute, Shengli Petroleum Administration, Shandong 257015, P. R. China). *Shiyou Kantan Yu Kaifa* 2000, 27 (6), 68-69. The key to fine reservoir description is building up the geologic model which can be used for quantitative description and expression to the reservoir sandstone and reservoir fluid. Guantao Formation of the west area of Gudao oil field is deposit of fluvial, which is characterized by scattered-distributing sandbody with rapid-variation in lateral. There are many difficulties in setting accurate geological model. By using advanced random geological modeling technology, we set up 3D-variation function of porosity, permeability and oil saturation. By optimizing the modeling methods, we employ index simulation to set up 3D geological model of the Guantao Formation, which could reflect the heterogeneous character of the reservoir parameters more precisely. From the study results, it is concluded that (1) the key to random modeling is to derive an exact variation function. Not only the exact variation function can evaluate the heterogeneity of reservoirs directly, but its degree of accuracy affects the accuracy of modeling effort; (2) Emphasis must be placed on the geologic constrain. It is imperative to select suitable geological model on the basis of understanding geological law completely and after full check using many methods; (3) the modeling is extremely difficult due to its specific characteristics of random modeling technology and difference between geological conditions, we can only use recent successful methods and examples on specified reservoirs. It must constantly study this difficult problem and sum up experiences; and (4) only by applying the random modeling technology to exploration and development and combining with the reservoir modeling technology can its superiority fully be manifested. **Subject heading:** Random modeling, Oil reservoir description, Variation function, Geologic model

The study and application of the seismic methods in oil and gas exploration in Upper Guantao Formation of Shenghai area. WANG Yan-guang; et al. (Computer center, Shengli Petroleum Administration, Shandong 257022, P. R. China). *Shiyou Kantan Yu Kaifa* 2000, 27(6), 70-73. The Shenghai area is one of the most important regions for oil and gas resource supplement of Shengli oil field. In this area, there are 7 oil-bearing formations including Minghuazhen, Guantao, Dongying, Shahejie, Mesozoic, Paleozoic and Archeozoic, among which Guantao has the most potential. However, it is quite difficult to perform the exploration because of very thin reservoir, large change of reservoir in space, a few drills etc. In this paper, the seismic-geological properties and reservoir characteristics are studied on the basis of well log analysis, geological model and seismic modeling. Some effective seismic methods are put forward , which are the post-stack multi-attribute analysis technique, the pre-stack gather analysis technique directly used for oil and gas prediction and the stack velocity application technique. Drilling proves that the techniques mentioned above are very effective, which reduces the quite high cost of drilling and the