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遥感技术在黑龙江省油气勘探中的应用

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摘要：遥感技术是对卫星遥感图像进行处理、解译，从而获得所需信息的一种技术，因此被广泛用于地质研究、矿产普查及环境检测等领域。利用遥感技术进行油气勘探，不仅形象，具有宏观性，而且能在较大区域内进行研究，比较适用于早期的油气资源调查。在对黑龙江省所辖盆地应用遥感技术进行油气资源调查过程中，利用 TM 图片的线性影像、环形影像所反映出来的地质特征并通过与已知油气区对比，建立了影像地质特征与含油气区分布之间的关系，预测了黑龙江省的有利含油气区。通过对其线性影像与环形影像的解译，为预测油气藏的分布提供了依据。

关 键 词：遥感；黑龙江省；石油；天然气；勘探
中图分类号：TE19 **文献标识码**：A

1 引 言

黑龙江省沉积盆地位于西伯利亚板块与中朝板块之间，由布列亚-佳木斯、松辽、额尔古纳等微板块及围绕这些微板块的造山带共同组成。构造演化主要受燕山期和海西期构造运动的影响，形成了与之密切相关的古生代和中新生代构造层。由于各种隐伏的地质体及结构与地表有内在联系，因此可以把控制油气分布的构造与受油气藏影响的地貌特征结合起来进行油气远景预测。从黑龙江省所辖盆地的石油地质概况看，松辽盆地的发育受断裂控制，基底断裂带不仅控制了油气形成与演化，而且对油气藏的形成起到至关重要的作用，其它外围盆地的勘探程度底，布局分散，地表比较复杂。将勘探程度高的松辽盆地作为刻度区进行影像特征对比的结果表明，应用遥感技术进行早期油气调查具有一定的可行性[1]，因此在黑龙江省所辖盆地开展了油气资源调查研究。

2 遥感资料处理

2.1 图像的特殊处理

以地质为目的的图像处理方法很多，但对覆盖区进行组合处理的方法效果最好[2]。组合处理方法是将局部统计增强程序和彩色级上色程序组合起来使用，可归纳为 4 个步骤：

(1) 扩展调整

有选择地扩展某一段，以充分增强研究对象之间色彩的差别。

(2) 局部增强

对图像进行统计增强处理，其公式为

$$I' = \frac{\delta_n}{\delta_0}(I - \mu_0)$$

式中 μ_0 ——期望均值；δ_0 ——期望方差；δ_n ——统计方差；I ——初始像元灰度；I' ——输出像元灰度。

(3) 假彩色赋值

通过跟踪球将图像的亮度分成多个等级，并赋予不同的颜色值。

(4) 补偿调节

运用图像处理程序对处理过程中的图像亮度损失值进行必要的补偿调节。

2.2 图像处理效果分析

将经过特殊组合处理方法得到的图像与已知含油气区、地质构造和黑龙江地质图进行对比的结果表明，研究区内主要的嫩江、依兰-舒兰、敦化-密山、牡丹江等深大断裂在处理后呈明显的线性图像，其走向及长度与实际相符。而松辽盆地现已发现的含油气区带（大庆长垣、三肇、齐家-古龙等）在处理后呈现明显的环形图像，图像界限明显，颜色差异清晰，区域范围准确，充分说明处理后的影像及其异常边界不仅更加清晰，而且色调饱满、层次丰富、信息突出。从遥感图像的初步地质解译看，全区第三纪所覆盖的深大断裂构造、盆地的边界范围和油田的分布与遥感影像吻合，可以用于剖析已知油气田区和预测新的含油气区。

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3　已知含油气区图像的地质解译

3.1　线性影像解译

线性影像是构成影像特征的基本要素之一。该地区图像资料的初步分析表明，不同长度、不同规模和不同表现程度的线性（包括带状）影像，大部分是地下不同深度、不同时代和不同规模断裂的反映[3]。

经对比，该区各种图像上的线性影像的方位频率基本一致。在区内共解译出线性及带状影像 69 条，其中大于 300 km 的有 3 条，200～300 km 的有 10 条。在大于 100 km 的 38 条影像中，多数为断裂反映。从展布方位看，有北东向、北西向、南北向及近东西向 4 组，尤以北东向、北西向两组断裂最为发育。北东向断裂是区内规模最大、数量最多、影响最深的断裂构造；北西向断裂虽然规模不大，但在后期对盆地有较大的改造作用，尤其对油气的聚集和保存有重要影响，这是值得重视的。如果从 4 组断裂形成的新老关系分析，则东西向和南北向两组断裂形成最早，对盖层（主要是第三系及第四系）影响最小，而发育最晚的是北西向断裂组。

从遥感解译图（图 1）可以看出，线性影像与油气田的位置有较好的对应关系。其中，线性影像 L18 为白色，其左侧为浅红色，右侧为浅蓝色，与实际资料对比为孙吴-松辽断裂，在该断裂的周围相继发现了喇嘛甸油田、萨尔图油田、杏树岗油田等 6 个特大型油气田。L14 为深蓝色，为嫩江河道，其左侧为浅红色，右侧为深红色，与实际资料对比为嫩江断裂，在该断裂发现了富拉尔基油田；L3-1 为深蓝色，为松花江河道，其南北均为浅蓝色，与实际资料对比为松花江断裂，在该断裂发现了临江油气田。L5 分 3 段：左段为蓝色（其南北为浅红色）；中段为白色（其南北为浅红色）；右段为深蓝色（其北为深红色，其南为绿色）。L5 为滨洲断裂，在该断裂发现了榆树林、尚家、齐家北油气田。在以上线性构造附近发现的油气田占全盆地已探明储量的 80 %。

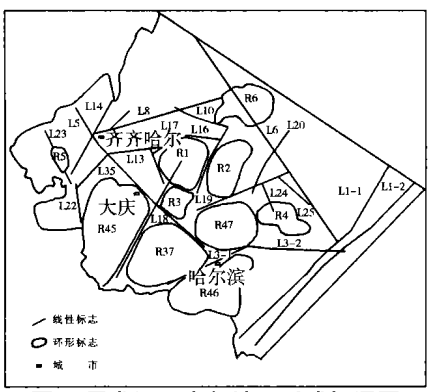


图 1　黑龙江西南部地区遥感解译图

3.2　环形影像解译

环形影像是指图像上具有环形、圆形或块状几何形态的影像异常。由不同色调的影纹或纹理构成，也可以通过水系的异常分布反映出来。事实表明，环形影像是地表、地壳或更深部的块状地质结构（如隆起、坳陷或各种火山机制等）的反映。由于它们的形状、结构和成分与周围介质相比存在多种差别，因此成为地质解译时的判别标志。在研究区内，共解译出 47 个环形影像（面积大于 1 000 km^2 的有 31 个）。其中，面积大于 10 000 km^2 的有 4 个，面积为 5 000～10 000 km^2 的有 5 个。

地质解译的判别标志具有明显的相对性，特别是色调的含义变化常取决于不同的地质、地理背景。如环形影像 R6 内为浅绿色，周围被红色和深蓝色的湖泊、河流包围，经与实际资料对比确定为松辽盆地三肇凹陷。在该凹陷内，目前已发现大—中型油气田 12 个；环形影像 R45 内为浅红色，其东部为浅绿色，其余部分被红色和深蓝色的湖泊、河流包围，经与实际资料对比确定为松辽盆地齐家-古龙凹陷，目前已发现大—中型油气田 8 个。

4　有利含油气区预测

4.1　有利含油气区

(1)　绥化地区

该区位于黑龙江省松辽盆地东部，在遥感解译图上表现为近东西向的环形标志（R47），反映了绥化断陷的轮廓，环形内为浅绿色，周围被红色和河流线包围，面积约 7 000 km^2。该区的影像颜色与其西南部已发现的油气区颜色一致，地理位置靠近油气源区，区内西南方向的东 5 井、东 8 井为工业气流井，中部的永 1 井见气显示，因此把该区作为一个有利的油气勘探区。

(2)　双城地区

该区位于黑龙江省松辽盆地东南部，在遥感解译图上表现为北东向的环形标志（R46），反映了王府断陷的轮廓，环形内为浅绿色，周围被河流线、杂乱的深绿色和红色包围，面积约 7 500 km^2。该区的影像颜色与其西北部已发现油气区的颜色一致，地理位置靠近油气源区，区内的庄深 1 井获工业气流，因此把该区作为一个有利的油气勘探区。

(3)　黑鱼泡地区

该区位于黑龙江省松辽盆地中部，在遥感解译图上表现为北北东向的环形标志（R1），反映了林甸断陷的轮廓，圆形内为浅红色，四周被深绿色及深红色包围，面积约 3 500 km^2。该区的影像颜色与其西南

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部已发现的油气区颜色一致，地理位置靠近油气源区，其中部的双深4井见气显示，因此把该区作为一个有利的油气勘探区。

(4) 绥棱地区

该区位于黑龙江省松辽盆地中部，在遥感解译图上表现为北北东向的环形标志（R2），圆形内为红色，四周被蓝色河流线及浅绿色包围，面积约4 000 km^2。该区的影像颜色与其西南部已发现的油气区颜色一致，地理位置接近油气源区，因此推测为一个有利的油气勘探区。

(5) 依-舒地堑

该区位于黑龙江省中部，在遥感解译图上表现为一个北东向的双线性标志（L1-1、L1-2），该线性标志贯穿黑龙江省，向北到达俄罗斯境内，向南到达吉林省。有关地质资料表明，此线性标志的地质背景为依兰-舒兰断裂带，是郯-庐断裂带北延的重要分枝，面积约为10 000 km^2。该地堑在吉林境内的部分区域已发现石油储量近亿吨，在黑龙江省的汤原、方正地区也提交了天然气储量，因此把该区作为一个有利的油气勘探区[4]。

4.2 较有利的含油气区

(1) 漠河盆地

漠河盆地在遥感图像上表现为5个环形标志，其内部主要为绿色，从周围的红色中突出出来，不但反映了坳陷区的宏观特征，也反映了坳陷区内部结构特征，为找油奠定了较好的物质基础。重力、磁力及区调资料显示，该区具有一定的生、储、盖条件，但不同构造单元的生、储条件不同，分析认为额木尔河凹陷最为有利，主要表现在3个方面：①凹陷面积大，基底埋藏深；②额木尔河和二十二站组地层发育，主要分布在中央坳陷区，且存在半深湖相泥岩沉积；③该区暗色泥岩已达到成熟或高成熟。因此，推测该区为较有利的油气勘探区。

(2) 孙吴-嘉荫盆地

在遥感解译图上，该盆地的边界主要被线性标志所控制，区域内颜色为浅黄、浅绿色，重力、磁力等物探资料表明为断陷盆地。其中，面积较大的断陷有嘉荫断陷和沾河断陷，其埋藏较深、泥岩发育、有机质丰富，具备形成油气的条件，是目前油气勘探的有利地区。

(3) 三江盆地

在遥感解译图上，该盆地的边界主要被线性标志包围，面积较大，区内颜色为红色，周围为绿色。现有的石油地质资料表明，三江盆地是中新生代断陷盆地，共划分出4个一级构造单元，其中绥滨坳陷面积大，沉积厚，埋藏深，井显示好。地质综合分析认为，三江盆地是比较有利的勘探区。

5 结 论

(1) 利用遥感技术的线性影像，可以研究区域性深大断裂的展布及其分布规律，从宏观上研究深大断裂与有利含油气区的关系，从而预测有利的含油气范围和聚集带。

(2) 利用遥感技术的环形影像，可以从区域上划分盆地边界及盆地内部断陷带的展布规律，从而确定沉积盆地边界和有利的生油断陷带。

(3) 通过已知油气区影像特征的识别，可以进行类比、分析，从而预测新的油气田区。

建议在今后的影像处理过程中充分考虑油气地球化学场对于地表所产生的波谱影响，以使影像图能够反映更多的物理、化学信息，同时应加强遥感图像信息与石油地质构造关系研究，使遥感技术研究再上一个新台阶。

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处理碳酸盐岩中沥青质沉积的新技术

在本文介绍的项目中，试验用蒸汽处理受到损害的灰岩岩心。进行了几项动态试验，以便确定沥青质对灰岩岩心的渗透率的影响。通过与在原油流过岩心前后测量的参考渗透率进行比较，评价了由于沥青质沉积造成的堵塞损害。然后用蒸汽浸泡方法对受到损害的岩心进行处理。每次处理后，测定岩心的渗透率。通过试验发现，取决于岩石的渗透率和注入的油量，由于沥青质沉积使原来原油的渗透率降低了56 %～89 %。取决于岩石的渗透率，经过采用蒸汽浸泡方法处理，受到损害的岩心的渗透率提高了24 %～230 %。受到损害的岩心的渗透率平均提高了95 %。

津强摘译自《SPE68766》

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Difference of Gas Accumulation Conditions on Ancient Uplift in Deep Strata of Daqing Placanticline and Its East

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Abstract : According to the gas distribution characteristics in deep strata of Daqing placanticline and its east, this paper pointed Anda-Zhaozhou and Chaoyanggou-Zhaodong ancient uplift to be the gas migaration direction and the gas accumulation place. Based on analyzing the difference of gas accumulation conditions, this paper studied the cause why the gas displays on Anda-Zhaozhou ancient uplift are better than on Chaoyanggou-Zhaodong ancient uplift, and studied the cause why the gas displays in Changde, Weixing-Shengping, Wangjiatun structures are better than in Mofantun-Zhaozhouxi structure.

Key words : Daqing placanticline and its east; deep strata; ancient uplift; gas; accumulation condition; defference

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Control on the Oil and Gas Reservoirs by the Structural Evolution of Tazhong Low Uplift in Tarim Basin

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Abstract : Tazhong low uplift in Tarim Basin has undergone modification of multiphase tectonic movement, which means four times of tension and four times of extrusion corresponding to the four times of major subsidence and rise. And the early, mid and late Caledonian movement and the early and late Hercynian movement are the main structural events for the structure forming as well as oil and gas accumulation in this area. So by the control of the structural evolution, two major reservoir forming periods of the Caledonian-early hercynian and the Yanshan-Himalayan have been formed as well as multi groups of source-reservoir-seal assemblage. And the structural development has also controlled the forming, preservation, destruction and setting of the reservoirs of different series of strata in different structural belt. Thus, many kinds of hydrocarbon reservoirs have been formed such as Carboniferous Donghe sandstone massive oil pools, Silurian layered pools and asphalt and Ordovician limestone interiors and weathering crusts. And by the influence of the structural movement, oil-gas accumulation has been formed in No. 1 Tazhong structural belt and north slope zone. So the structure in the northwestern periclinal area of tazhong low uplift is fairly stable and has the geologic setting to form large oil-gas field, being the new area for next step of oil and gas exploration.

Key words : Tazhong; structural evolution; hydrocarbon reservoir; palaeohigh; oil and gas richness degree

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Study on the Fault Sealing Properties of Fault AN2-F0 of Anticline AN2 in Tarim Basin

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Abstract : In this paper, on the basis of the existing study on the faults sealing properties, some indexes are analyzed, such as fault activity, lithologic juxtaposition section of fault, the sand-shale ratio of fault-slip strata, daubing coefficient, the relationship between the pressure of fault surface and the sand-shale ratio. It is determined that fault AN2-F0 of anticline AN2 is sealed well, forming the effective oil-gas trap.

Key words : fault AN2-F0; fault sealing property; effective oil-gas trap

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Stratum Deformation and Solution of Thickness of Inversion Denudation in Songliao Basin

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Abstract : The comeback of thickness of inversion denudation relates to the well and true recurrence of the developmental course of generation, migaration and accumulation for oil and gas. The key of the solution is to establish the stratum deformation model. Based on the explanation of plentiful seism information for the middle and shallow stratum, it makes sure that the era of stratum deformation in Songliao Basin is from the end of Mingshui Formation to the deposit end of Tertiary. Two kinds of the stratum deformation model for capping layers are also founded, such as the type of plastic flow and the type of inter-laminated detachment. It uses the principle of area conversation to calculate the thickness of denudation to the two models above. This paper analyzes the characteristic of inversion denudation in Songliao Basin and presents the recognition that inversion section of the structure is the most advantageous part of oil and gas accumulation.

Key words : stratum deformation; inversion denudation; Songliao Basin

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Research on Sedimentary Microfacies Using Sequential Indicator Simulation

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Abstract : It is difficult to determine and classify the boundary of sedimentary microfacies in the study of reservoir sedimentation. This paper applies sequential indicator simulation to model the spatial distribution of sedimentary microfacies of Chang4 + 5_2 in P oilfield. Sequential indicator simulation approach is a kind of stochastic modeling method based on indicator Kriging. The result shows that this approach not only demonstrates the variation of microfacies, but also overcomes the uncertainty of the models due to the lack of data. It gives a solid geological foundation for forecasting reservoir parameters in the further study.

Key words : sedimentary microfacies; reservoir heterogeneity; sequential indicator simulation

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Reservoir Microproperty of Sandstone-Conglomerate Body in Lijin Area

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Abstract : Sandstone and conglomerate body in Lijin area in north slope of Dongying depression is a nearshore subaqueous fan reservoir which is the forth member of Shahejie formation. Sand and conglomerate are the main rock types. The reservoir is of the lithological characteristics of low composition and structure maturity, and bimodal or polymodal structure. Firstly this paper describes the diagenesis influencing the performance of reservoir. Then pore types and feature of pore structure are analyzed. The reservoir of sandstone and conglomerate body in Linjin area possesses sorts of pore types, complex pore structure, middle-low porosity and low permeability.

Key words : Lijin area; sandstone and conglomerate body; diagenesis; pore structure; low permeable reservoir

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Application of Remote Sensing Technology on Oil-Gas Exploration in Heilongjiang Province

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Abstract : Remote Sensing Technology can get all kinds of information by Processing and Interpreting remote sensing image, it is abroad used in geology research, mineral survey and environment monitoring,

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etc. Remote sensing technology can research in large area and suit for early exploration of oil and gas. Through the application of remote sensing technology on exploration of oil and gas in Heilongjiang Province, it built connection between trace geological characteristics and distribution of oil and gas field by contrasting TM image's line trace and round trace geological character with known oil and gas field characteristics, and forecasted possible oil and gas fields.

Key words: remote sensing; Heilonjang province; oil; gas; exploration

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Testing Technique of Loose Core Preparation and Its Physical Properties

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Abstract: In order to obtain complete and accurate parameters of core physical properties, the freezing sealing preparation and testing technique of loose core is improved, the influence of the technique on porosity, peameability and oil-bearing/water-bearing saturation is discussed. Through comparing with the former and this new methods, the conclusion is obtained, which is that variation volume of core physical property parameters before and behind freezing is usually direct ratio with loose degree of core samples; a complete set method of taking oil-bearing and water-bearing saturations of loose core of sealing coring using liquid nitrogen freezing sealing preparation, alcohol extracting water from core and spectrophotometry testing tracer content etc. is given. The testing result shows that the method can meet the request of core deoil, drying and rock physical property testing; after the obtained data of porosity, peamebility and oil-bearing and water-bearing saturations are corrected, the impacts of freezing technique on rock physical property parameters are decreased; A problem that is difficult to test porosity, peamebility and oil-bearing and water-bearing saturations etc. in same core is solved, not only the impact of core heterogeneity is eliminated but also data comparability is improved.

Key words: loose core; freezing; core sealing preparation; physical property parameter; correction

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Increasing the Development Comprehensive Benefit of Complicated Fault-Block Oilfield

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Abstract: This paper takes Wenliu complicated fault-block oilfield as an example, classifies and induces the applying situation of special drilling and 4 inch casing completion in $5\frac{1}{2}$ inch or 7 inch tube well technology used in various reservoirs and different development stages. The research result is that special drilling and new well completion technology has distinctive effect on improving oilfield development and increasing the development comprehensive economic benefits. At the same time, the following viewpoint can be obtained that special drilling technology is the dominant drilling technology for making complicated fault-block oilfield's economic and high-effective development, 4 inch casing completion in $5\frac{1}{2}$ inch or 7 inch tube well technology is an effective way of removal casing worsen and realizing the subdivided development of series of strata.

Key words: special drilling technology; complicated fault-block oilfield; 4 inch casing completion in $5\frac{1}{2}$ inch or 7 inch tube well; increasing benefit

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The Distribution Patterns of the Interlayers within Thick Pays and Their Impact on Recovery Efficiency, Shuanghe Oilfield

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Abstract: During the late period of development, the interlayers and their distributions have significant implications, because the interlayers within thick pays control the types of waterflooding and the basis of justifying the injection and production structures. The interlayers within thick pays and their influence on recovery efficiency in Shuanghe oilfield are dissected in this paper by using sealed coring data, closely spaced wells, waterflooding log evaluation, numerical simulation and performance data. The analyses indicate that the interlayers which developed in the thick pays of Shuanghe oilfield are composed of dark grey or grey mudstones, silty mudstones, muddy siltstones, calcareous sandstones or conglomerates, muddy or silty sandstones and conglomerates; the upper cutoffs of physical properties of the interlayers are $20 \times 10^{-3}\mu m^2$ for permeability and 12.5% for porosity. With apparent electric characters, 95.6% of interscan be identified by SP log and mirclog. The distribution of interlayers can be divided into three patterns: stochastic, transitional, continuous. They show the differences of distribution of interlayers. The interlayers have substantial impact on production efficiency by impeding gravity flood/drainage or decreasing sweep efficiency. According to this knowledge, however, we took several measures such as alternative perforation, subdivision of development units, shut-in of high water cut layer, to optimize recovery. These measures have played important roles in stabilizing production and contrlling water cut.

Key words: thick pay; interlayer; distribution pattern; recovery efficiency

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The Productivity Study of Horizontal Well with Non-Complete Symmetry Multiple Well Bore

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Abstract: In order to better provide basic analytical method for research of reservoir engineering for flow of horizontal well, the stable flow of horizontal well with non-complete symmetry multiple well bore is researched according to pseudo-3-dimension idea and using conformal transformation and flow theory such as imaging theory and superposition principle and equivalent flow resistance method. Its flow pattern and productivity calculating formulas are derived, and these formulas are generalization of corresponding conclusions of horizontal well with non-complete symmetry multiple well bore. In addition, some factors of horizontal well with non-complete symmetry multiple well bore are analyzed, and the productivity of these wells is compared. The conclusion can be used to research and calculation and prediction of reservoir engineering for flow of horizontal well.

Key words: horizontal well with multiple well bore; non-complete symmetry; productivity; pseudo-3-dimension; stable flow

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Water Body and Convergence Problem in Reservoir Simulation

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Abstract: Reservoir numerical simulation is regarded as "modern reservoir engineering technique". In its application, the difficulty includes determining a suitable water body model and analyzing the cause of non-convergence. This paper uses ECLIPSE black-oil simulator to analyze the concept of grid water body, numerical water body, Fetchovich and Cater-Tracy analyzed water body, and flux flow boundary water body, which are usually used in reservoir simulation. It also discusses their definition, adjustment method, advantages and disadvantages. It shows that numerical water body is feasible and flexible, Fetchovich and Cater-Tracy analyzed water body has a high calculation speed. Secondly, starting from the mathematic definition, it analyzes the grid geometry design, PVT data, saturation fuction, and the de-

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