廊固凹陷中西部下第三系天然气藏形成条件及富集规律*

张以明** 梁宏斌 张舒亭 欧阳华 张彦民
(中国石油华北油田)

张以明等. 廊固凹陷中西部下第三系天然气藏形成条件及富集规律. 天然气工业, 2002; 22(1): 33~ 37

摘 要 廊固凹陷是华北油田下第三系产气的主力凹陷, 是最早向京供气的产气区, 现在是陕京输气管线向北京供气的应急调峰的重点后备地区。文章主要从构造特征、天然气成因类型、生储盖组合特征、天然气保存条件等方面阐述了廊固凹陷中西部下第三系天然气藏的形成条件及富集规律。重点阐述了中浅层天然气的成因类型及天然气的成藏条件, 建立了该地区气藏的成藏模式。勘探实践证明, 该区天然气资源丰富, 构造、储层、运移与保存配置合理, 成藏条件优越, 完全具备形成较大储量规模的气田。尤其是旧州—固安构造带勘探程度较低, 又有多个有利构造, 应是比较现实的勘探领域。

主题词 廊坊凹陷 固安凹陷 天然气 油气成因 成藏条件 成藏模式

天然气藏形成条件

1. 区域构造背景及构造特征

廊固凹陷系渤海湾裂谷盆地冀中坳陷的一个西断东超的箕状凹陷。由于东翘西断作用, 西部大兴断层形成, 凹陷发育并开始接受沉积; 因大兴断层强烈活动, 东部河西务构造带隆起持续抬升, 造成了东高西低的地形; 北部桐柏镇断层在东翘西断的后期开始形成并活动, 沙三末期后, 南部牛驼镇凸起抬升, 使得该断层也强烈活动, 造成凹陷的沉积中心由大兴断层下降盘向桐柏镇断层下降盘转移, 形成了现今南高北低的构造格局。

由于局部应力场及重力作用, 地层顺大兴断层、河西务西断层严重向下滑脱, 并使地层顺 $Es_3^{4\sim 2}$ 底界面附近产生滑脱, 造成凹陷中部地层肿胀挤压上拱, 而形成大型挤压背斜构造。

背斜的轴部是柳泉—曹家务构造带, 其西翼就是旧州—固安构造带。

受区域右旋应力场及局部应力场的共同作用, 使得该区具有较复杂的构造特征与断裂系统。一是北东方向受区域右旋挤压应力场的作用, 形成旧州—琥柏营、石佛寺—王居、固安—柳泉、固安南—前石家务等多个背斜构造; 二是北西方向受区域右旋拉张应力的作用, 稍晚又形成与大兴断层斜交的羽状南掉断裂及其补偿断层。

多期构造运动使本区地层形成了四个区域性的不整合接触: 下第三系与古生界之间的不整合, 第三系内部沙三段与沙四段之间, 沙二段与沙三段之间, 上第三系与下第三系之间的不整合。另外, 还可能存在沙一与沙二、东营与沙一之间的局部不整合。由于断层的切割作用, 该区形成了大量的断鼻、断块构造, 配以沙三中良好的储盖组合及其充足的油源条件, 使得该区具备了形成以构造油气藏为主多种油气藏类型的条件。

2. 烃源岩特征[1]

凹陷西部的主要生油层系是沉积于较深湖环境中的沙三段暗色泥岩, 最大厚度可达 1 000 m 以上。沙三段又分为沙三下、沙三中、沙三上, 为一套由下至上由好到差的生油岩。其母质类型以 Ⅱ2~Ⅲ的陆源高等植物为主, 生成的烃类以气态烃和凝析油为主, 形成了该带构造带气多油轻的条件。

* 本文系中国石油天然气集团公司"廊固凹陷旧州—固安构造带综合评价及目标优选"项目的部分成果, 编号 990102-1。

** 张以明, 高级工程师, 1959 年生; 1982 年毕业于西南石油学院, 1990 年获硕士学位; 现从事现场生产管理、综合研究, 勘探项目管理工作; 曾获省部级奖 5 项, 发表论文十余篇。地址: (062552) 河北省任丘市。电话: (0317) 2721823。

据该区生油综合剖面,沙三段烃源岩在沙三末古埋深开始大于3 000 m,即进入低成熟阶段,因此,大量生烃期和排烃期应是在沙三末或沙二至东营组末期以后。到4 400 m就达到湿气门限,反映出纵向上湿气门限浅、生气带较长、气多的特点。西部之所以湿气阶段埋深浅,主要有以下原因:㈠侵入岩的影响,这一带深层辉绿岩、辉长岩侵入体很普遍,致使古地温升高;㈣强烈的后期抬升和剥蚀,致使古温大于今古地温。

3. 天然气成因类型

廊固凹陷天然气的形成作用具多源性和多阶段性,加之其特殊的地质环境(构造演化、断裂发育伴随岩浆活动,早第三纪末期遭受长期剥蚀等),造就了多元化的天然气成因类型。参照戴金星、徐永昌分类方案,结合本区实际情况将天然气划分为生物气、生物改造气、生物—热催化气和热解气。

(1)生物成因气

生物气气藏的埋深一般小于1 750m,其地化特征主要有以下几点:㈠天然气组分中,甲烷含量大于95%;㈣甲烷碳同位素较轻,这是生物气最典型的特征之一,本区$\delta^{13}C_1$一般为-55‰~-60‰,最轻可达-61.7‰;㈣以纯甲烷气藏为特征,一般没有伴生轻质油或凝析油。

(2)生物改造气

正常热演化形成的天然气经后期生物作用,使其地化特征发生变化而重新形成天然气,具有明显的运移特征。其主要地化特征为:㈠湿气含量低,甲烷碳同位素分布范围较宽;㈣生物改造气常与生物降解油伴生;㈣气油比较大,具反常的油气演化趋势。

(3)生物—热催化过渡带天然气

主要分布于1 800~3 200 m,大多在2 000~3 000 m之间,这是受母质类型差异和地温场不同所决定的,其有机地化特征为:㈠天然气甲烷碳同位素、氢同位素较轻,该类天然气的$\delta^{13}C_1$除比生物气重外,比其它各类成因类型的天然气都轻,大部分为-48‰~-52‰;㈣天然气组分中湿气含量较高,甲烷含量相对低,湿气含量高是生物—热催化气的重要特征。天然气的甲烷含量比其他各类天然气都低,甲烷含量小于77%,湿气含量平均在20%~30%,$C_1/(C_1\sim C_5)$分布范围大,为0.67~0.87;㈣常与轻质油或凝析油伴生生物—热催化天然气可与其相应的低熟轻质油或凝析油伴生。对该种成因类型的工业气井统计发现,其伴生油的密度小于0.8 g/cm^3,一般在0.72~0.78 g/cm^{3}之间,为轻质油或凝析油。

(4)热解气

相对应于石油热演化的成熟阶段,R_o为0.5%~2.0%,在热催化作用过程中形成的气体,又称热催化气,气藏埋深2 000~5 000 m不等,大部分埋深大于3 000 m。主要地化特征有如下几点:㈠甲烷碳同位素-39‰~-46‰,氢同位素大于-200‰;㈣湿气含量5%~50%,大部分为5%~20%,甲烷含量大于70%,$C_1/(C_1\sim C_5)$为0.78~0.92。

中西部浅层气类型主要为前三种类型。

4. 储层特征

沙三段沉积时期,物源主要来源于西部的大兴凸起方向,早期沿大兴断面沉积了大套砾岩冲积扇群,中后期在凹陷中西部沉积了分布范围较广的扇三角洲前缘砂体,凹陷东部则以滨浅湖相泥岩为主;至沙二段沉积时期,物源又以东部方向为主,在河西务构造带中南部沉积了三角洲前缘砂体,朝北西方向则相变为以泥岩为主的湖相沉积。这种沉积环境的频繁更叠在纵向上为油气藏的形成提供了多套良好的储盖组合。

沙三中段砂体是廊固凹陷中西部的主要储层。以扇三角洲为主的砂体类型。扇三角洲砂体,呈北东向展布,宽约7 km,长约20 km,面积140 km^2,横向上扇三角洲砂体的堆积逐渐由西向东,向南迁移。在纵向上主要分布在沙三中段(分Es_3^{4-1}、Es_3^{4-2})。砂岩储层与暗色泥岩呈不等厚互层,埋藏浅—中等,物性为中孔低渗—特低渗,气产量$2\times10^4\sim15\times10^4$m^3/d,产油量10~40 t/d。平面上储层物性具有南好北差的特点。

5. 盖层特征

盖层对油气藏的形成起重要控制作用,尤其天然气更是如此。中西部地区盖层主要为泥质岩类盖层,其对烃类的封闭能力是研究的关键。据研究,影响盖层封闭能力的主要因素有:泥岩中的砂质含量、成岩作用、泥岩厚度、地层压力等。

砂质含量对封闭能力有较大影响。随着砂含量增加,封闭能力减弱。但不同深度影响程度有一定的差异。埋深较浅时,砂质含量对盖层性能的影响十分明显,如安98井2 645 m泥质粉砂岩的排替压力为0.47 MPa,而埋深大致相同的京36、泉84、安62井的粉砂质泥岩的排替压力为0.82~1.27 MPa;当埋深大于3 000 m时,地层静压力导致压实作用更加强烈,泥质粉砂岩的孔隙度、渗透率大大降低,

泥质粉砂岩与粉砂质泥岩的遮挡能力变得很相近, 如务 7 井 3 210 m 处的泥岩含粉砂 5%, 排替压力为 2.83 MPa, 务 10 井 3 465 m 粉砂质泥岩含粉砂 25%, 排替压力为 2.81 MPa, 数据很接近。

统计结果表明, 处于早成岩阶段 B 期—晚成岩阶段 A 期的泥岩, 封闭能力最佳。

从理论上讲, 盖层的封闭能力取决于排替压力, 而与厚度无关。但盖层厚度增大, 可以弥补其它条件的不足。表现在: 泥质岩厚度大, 反映水体深且稳定, 砂岩含量低; 泥岩单层厚度大于断层的断距时, 泥岩未完全断开易形成侧向封闭; 泥岩单层厚度大不利于水和烃类排出而形成欠压实带; 单层厚度大, 可以大大降低气藏中气体扩散速度。

储层的压力系数低, 则在相同埋深的情况下储层的剩余压力小, 甚至为负数, 利于气藏封存, 反之则不利。廊固凹陷地层压力系数纵向分布规律表明: ① 埋深 1 750 m 以上基本属于静水压力, 压力系数为 0.767~ 1.079; ④埋深 1 750 m 以下压力系数随埋深增大, 压力系数 1.03~ 1.67; ㈣不同地区压力系数有差异, 凤河营、旧州—固安、别古庄、中岔口压力系数低, 有利于天然气封存, 而柳泉、王居、琥珀营、杨税务、廊东地区地层压力系数高, 要形成天然气藏, 则对盖层有更高的要求。

6. 保存条件

好的保存条件应有两方面的保障: 一是构造的相对稳定性; 二是水动力相对低能和地下水的还原性。这两点在廊固凹陷中西部都有其特殊性。

一方面由于该区后期构造运动剧烈, 产生的断层增大了 $Es_3^{下}$ 巨厚烃源岩排烃、运烃的能力和机率, 同时被破坏的油气藏, 其油气可随着水流方向以及其它方向运移, 在有圈闭的地方重新聚集成藏, 形成次生油气藏。

另一方面, 以往认为旧州—固安构造带沙三中、上段地层水性质与其它构造带相比具有水淡、矿化度低的特点, 属水动力强交替区, 对油气藏的保存不利。泉 241 富集区块发现以后, 对该区的水动力条件又进行了深入分析, 认为水动力强交替区也可以形成小而肥的油气藏。由于地表水的渗入, 带入了大量的细菌, 使得未成熟烃源岩形成了与生物成因气有关的天然气。从大兴断层下降盘地层水总矿化度等值线图发现, 目前该区所发现的新泉 2、泉 107、固 13、泉 241、泉 68 等油气藏的地层水矿化度值都比较低, 很有可能是油气再次运移、聚集而成藏的 (见图 1)。

气藏类型及富集规律

1. 气藏类型

目前在中西部发现的油气藏主要有二种类型:

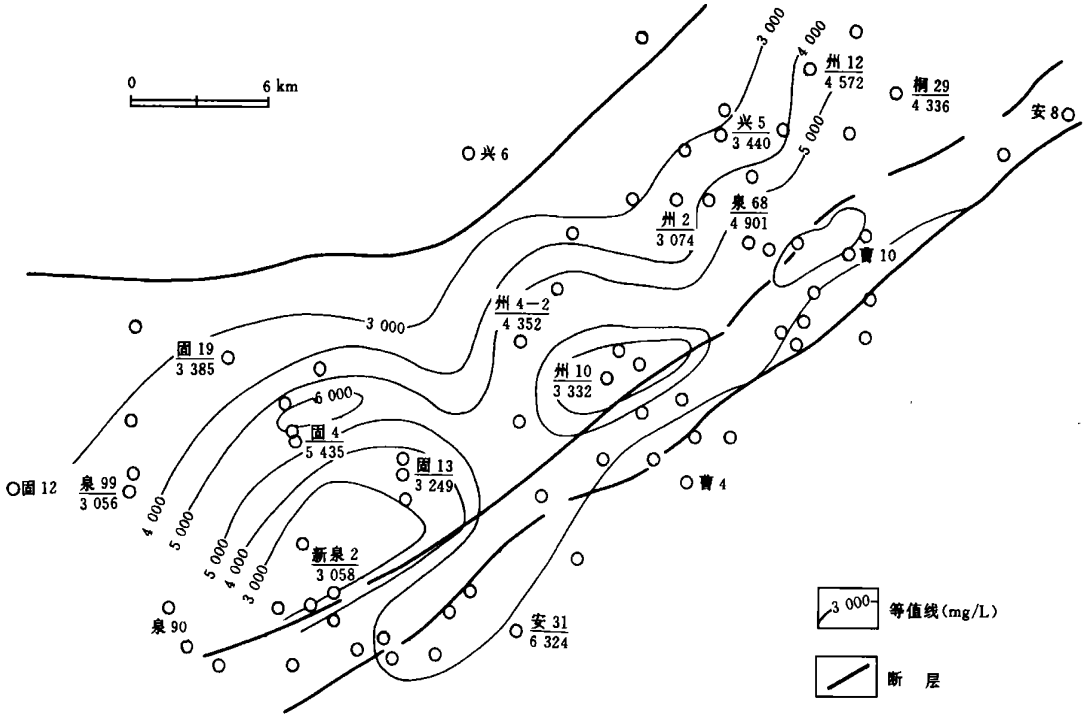

图 1　廊固凹陷中西部 Es_3^{4-1} 地层水总矿化度等值线图

即构造气藏、构造—岩性气藏。

构造气藏主要有二类构造气藏：即断块、断鼻油气藏。

(1) 断块气藏

可由反向正断层封挡形成的断块气藏，亦可由正向正断层封挡形成断块油气藏。如柳泉北构造固13井沙三中段气藏由北西向顺向正断层和北东向旧州西断层控制。可分为上下两个砂组，第一组为固13井北断层下降盘的气藏，受顺向断层控制；第二组位于固13井北断层的上升盘，与固131井同属于一个断块，是受反向断层控制的构造气藏。

(2) 断鼻气藏

如旧州—固安构造带南部的泉68井气藏，是由北东向旧州断层和北西倾的地层组成的断鼻构造气藏。

构造—岩性气藏的基本特点是天然气分布受构造背景控制，而具体含气部位却受岩性变化的制约，在平面上含油气范围总的看来与构造背景相吻合，但含气边界与构造等值线不一致。

构造背景上的砂岩上倾尖灭圈闭在以下层段中已经发现的有：Es_3^{4-1}和Es_3^3上部，如泉17井Es_3^3下部气藏，泉103井Es_3^{4-1}上部气藏属于构造—岩性气藏；二是沙三上粗段的顶、底部，如泉90、56井等。

构造气藏是中西部气藏的主要类型。

2. 富集规律

通过勘探实践，发现有以下几个显著富集规律。

(1) 油气分布受主生油洼槽控制明显

从两构造带已发现的油气藏分布情况看，其分布范围受生油岩分布范围的控制，构造带中北部靠近主力生油洼槽，生烃条件好，油气显示活跃，出油气井点多，发现的油气藏多，找到的储量亦多。而远离主力生油洼槽的前石家务地区虽然是油气长期运移的指向，但仅发现了泉13、14、18、90井几个出油气井点，油气并不富集，找到的储量也不多。这种分布特征一方面是由于油气侧向运移距离短，另一方面是南部生油岩品质差，形成的油气资源量比较少而造成的。

(2) 后期式煤成气型生物成因气广泛分布

生物气具有甲烷碳同位素均轻于－55‰，气体为干气的特点，在国内外发现于浅埋的、成煤作用中期的煤岩吸附气或运移至砂岩中的气体，其甲烷碳同位素一般小于－55‰，与煤岩的演化阶段不相符。这些天然气不是现今煤岩演化阶段中产生的，而是在后期的抬升至浅层时由于生物活动而产生的。华北油田与廊坊分院合作，开展了廊固凹陷微生物实验研究，证实廊固凹陷浅层后期式煤成气型生物成因气广泛分布。

(3) 纵向上多层段含气，但以沙三中段最富集

沙三中段为最有利的储盖组合，且埋藏适中，储层处于早成岩B期混合孔隙发育带，更有利于油气的聚集成藏；沙三下段，由于埋藏较深，大都处于早成岩的A期次生孔隙发育带，储层物性普遍较差；沙三上段尽管埋藏浅，储层物性好，但由于远离生油岩，油气资源不足而且储盖组合欠佳，尤其是盖层质量较差，对油气保存不利，不利于形成规模储量，但从中、浅层生油岩具有生成大量生物气的能力看，浅层如有大范围的低幅度构造，亦能形成富集块。

3. 成藏模式

中西部存在有二种成藏模式。

(1) 残余及次生油气藏成藏模式

指原生油气藏遭受了改造，使得油气部分或完全逸出而重新聚集成藏，留下的油气藏即为残余油气藏，重新聚集成藏的即为次生油气藏(见图2)。目前发现的大多数油气藏属此类，其分布于沙三段的各个层段，以沙三中、上段最为普遍。

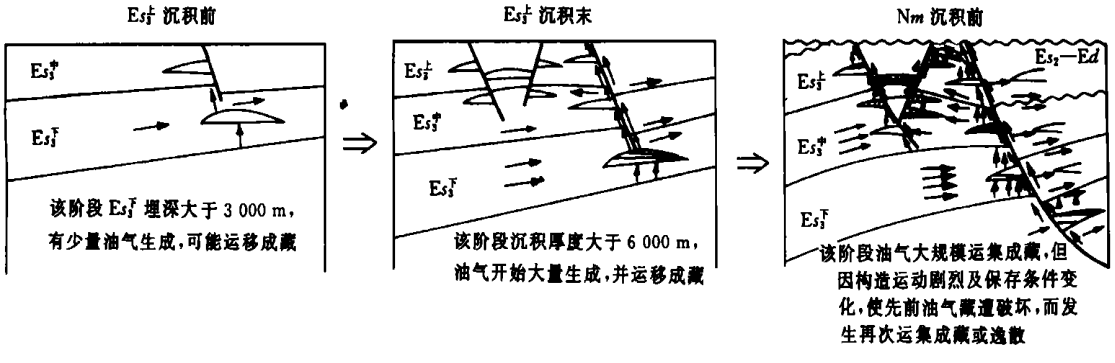

图2　廊固凹陷中西部成藏模式图

储层微观非均质性的分形特征研究

李云省*　　邓鸿斌　　吕国祥
(电子科技大学)　　(西南油气田分公司勘探研究院)　　(西南石油学院)

李云省等. 储层微观非均质性的分形特征研究. 天然气工业, 2002; 22(1): 37~ 40

摘　要　储层微观孔隙结构是影响储层储渗特性的重要因素。很多研究表明, 储层微观孔隙结构具有分形特征。但是, 由于储层微观孔隙结构不易用肉眼去分辨, 所以使得储层微观非均质性研究一直难以深入进行下去。文章将 PIA 技术与分形理论相结合, 在"计盒法"的基础上推导出了一种新的分形分析方法。该方法简单易行, 且不受人为因素影响。利用该方法, 对某油田三口井共 16 个砂岩薄片和 2 个碳酸岩盐薄片进行了分析, 结果发现该方法较传统非均质性分析方法更能准确地表征储层微观孔隙结构的非均质程度。

主题词　储集层　微观结构　非均质　岩石孔隙　分形学　图像分析

分形理论是研究自然界复杂系统的有力工具, 而储层微观孔隙结构是一个具有分形特征的复杂系统[1,2], 而且也是影响储渗特性的最主要因素。但是, 度量这种微观分形特征却是不容易的。因为人的肉眼分辨率的限制, 这种研究必须与其它手段一起才能进行。

PIA(petrographic image analysis)技术是石油地质工程师们用于岩心分析的常用方法。该技术通过对岩心切片进行图像分析, 能很好地评价储层岩石孔隙系统的微观特性。图 1 就是一个 PIA 普通输出。当然, 其中只代表这种技术性能的一小部分, 因为其它功能与此次研究关系不大, 故不予研究。

储层微观孔隙结构分析是一项难度较大的课题, 原因之一就是微观孔隙的度量比较困难。虽然目前出现了为数不多的几篇研究储层微观孔隙结构的文章, 但是, 所有这些文章都是处于一种理论探索阶段, 对于实际的微观孔隙结构并未提出一种实用的分析方法。因此, 本文试着将 PIA 技术与分形理论相结合, 寻找一种可以定量描述储层微观孔隙结构的方法, 借以填补目前该方面研究的空白。

孔隙结构分形维数的计算

储层微观结构的分形分析常用的是"计盒法"。该方法是利用不同规格的网格覆盖在图像表面, 然后统计出不同网格尺寸下的包含有孔隙的小方格的数量, 根据分形的标度关系式来求解分维 D。

$$N(r) \propto r^{-D} \tag{1}$$

式中: r 为小方格的边长。

"计盒法"的最大缺点是统计盒数 $N(r)$ 的过程, 该过程不仅繁琐而且人为因素太大, 从而影响结果的精度。本文所提供的方法简单易行, 且不受人为因素的影响。

设孔隙半径为 r, 通过筛选得到半径大于 r 的孔隙数量 $N(r)$, 如果 $N(r) = \int_r^{\infty} \rho(r')\,dr' \propto r^{-D}$ 成立, 则说明孔隙分布具有分形特征, D 为其分形维

(2) 生物成因气气藏成藏模式

指在未(低)熟阶段微生物直接作用于富含有机质的暗色泥岩生成的天然气进入圈闭而形成的气藏。其主要分布于沙三段的中浅层, 如新泉 2、固 131 等气藏。

参　考　文　献

1　戴金星. 天然气地质和地球化学集. 北京: 石油工业出版社, 1998

(收稿日期　2001- 10- 18　编辑　韩晓渝)

* 李云省, 博士, 1969 年生; 1999 年毕业于西南石油学院石油工程系; 主要从事测井信号处理及油气藏描述方面的研究工作, 现为电子科技大学博士后, 主攻信号处理研究, 已发表论文数篇。地址: (610054) 四川省成都市电子科技大学电子工程学院 702 教研室。电话: (028) 3252302。

SOURCE ROCKS AND GENERATION & EVOLUTION MODEL OF NATURAL GAS IN YINGGEHAI BASIN

Huang Baojia and Xiao Xianming (Guangzhou Institute of Geochemistry, Academia Sinica) and Dong Weiliang (Research Center of CNOOC).
NATUR. GAS IND. v. 22, no. 1, pp. 26~30, 1/25/2002. (ISSN1000-0976; **In Chinese**)

ABSTRACT: There are two series of hydrocarbon source rocks, i.e. Miocene and Oligocene source rocks, in Yinggehai Basin. The Miocene marine source rocks are considered to be the major ones of the diapiric shallow gas fields in the basin owing to their medium abundance organic matters and the kerogen's being mainly derived from terrigenous high plants and partially from phytoplanktons. The character of mainly generating gas in Miocene is determined by the high geothermal gradient of the basin and by the source rocks rich in the organic matters of tendency-humic mixture type and humic type. Through thermal simulation experiments and in combination with the distribution characteristics and geological conditions of the gas fields found and with the paragenetic relation of the key components of natural gas in the fields, the gengeration periods and interrelation among hydrocarbon gas, carbon dioxide and nitrogen were profoundly investigated and a generation & evolution model of the natural gas originated from the Miocene hydrocarbon source rocks was set up so as to provide some valuable geochemical data for natural gas exploration in the basin.

SUBJECT HEADINGS: Yinggehai Basin, Miocene epoch, Gas source rock, Gaseous hydrocarbon, Carbon dioxide, Paragenesis, Gas reservoir formation

Huang Baojia *(senior engineer)*, born in 1960, graduated in Petroleum geology at the Southwest Petroleum Institute in 1982. Now he is studying for his doctorate in the Guangzhou Institute of Geochemistry, Academia Sinica and engaged in the research on applied petroleum geochemistry. He published several articles. Add: Zhanjiang, Guangdong (524057), China Tel: (0759)3800573

……

CARRYING BED SYSTEMS AND OIL & GAS MIGRATION IN YILAN-YITONG BASIN

Liang Chunxiu (Chengdu College of Technology) and Wei Zhiping, Li Bencai and Sheng Jiubin (Research Institute of Petroleum Exploration and Development, Jilin Oil Field).
NATUR. GAS IND. v. 22, no. 1, pp. 31~32, 1/25/2002. (ISSN1000-0976; **In Chinese**)

ABSTRACT: The path of oil and gas migration is called a carrying bed. Through an investigation, it is shown that there are three types of carrying beds, i.e. sandbody reservoir, basement rock unconformity and fault, in Yilan-Yitong Basin. The sandbody reservoir and basement rock unconformity may be mainly taken as the paths of lateral oil and gas migration, and the fault may be taken as both a barrier and path of oil and gas migration, being dependent on the character and activity strength of the fault. As the path of migration, the fault is mainly taken as the path of vertical oil and gas migration or plays a role in hydrocarbon's being directly lost at the surface. Yilan-Yitong basin may be divided into three second-order tectonic units, such as Chaluhe, Luxiang and Moliqing Depressions. Controlling the oil and gas migration, accumulation and distribution, the carrying bed systems in the three depressions are different from each. They are: ① the oil and gas migration and accumulation in Moliqing Depression were mainly at a short distance, and the basement rock unconformity and fault created conditions for a relatively long-distance migration also; ④Member Shuang-2 sandstone is an excellent carrying ded that caused the oil and gas generated in Danan Seg of Luxiang Depression to be massively migrated toward Wuxing structural belt; and (四)the fault in Chaluhe Depression is taken as the path of vertical oil and gas migration, playing a dual role, i.e. either making the deep-buried reservoirs be destroyed or making the shallow reservoirs be formed.

SUBJECT HEADINGS: Oil and gas migration, Vertical migration, Lateral migration, Barrier (geology), Delivery, Yilan-Yitong Basin

Liang Chunxiu *(female)*, bon in 1959, graduated from the Daqing Petroleum Institute in 1983. She has been engaged in oil-field development research and management successively in the research institute of Jilin Oil Field and the Jilin Oil Field Branch Company and published three articles and a book. Now she is an on-the-job postgraduate studying for her doctorate in the Chengdu College of Technology. Add: Songyuan, Jilin (138000), China

……

FORMATION CONDITIONS AND ACCUMULATION LAWS OF PALEOGENE GAS RESERVOIRS IN WEST-MIDDLE LANGFANG-GU'AN SEG

Zhang Yiming, Liang Hongbin, Zhang Shuting, Ou'yang Hua and Zhang Yanmin (North China Oil Field, PCL).
NATUR. GAS IND. v. 22, no. 1, pp. 33~37, 1/25/2002. (ISSN1000-0976; **In Chinese**)

ABSTRACT: . Langfang-Gu'an Seg is the major seg, where

natural gas has been produced from Paleogene, in North China Oil Field, being the gas-producing area of earliest supplying natural gas to Beijing, and now it is the key reserve area of emergency peak shaving for supplying gas to Beijing with Shaanxi-Beijing gas pipeline. In the paper, the formation conditions and accumulation laws of paleogene gas reservoirs in West-Middle Langfang-Gu'an Seg are expounded mainly according to structural features, gas genetic types, source-reservoir-seal assemblage characteristics and gas preservation conditions, etc., and the genetic types and reservoir formation conditions of medium-shallow natural gas are emphatically stated through setting up a gas reservoir formation model for this area. It is proved in practice that the reservoir formation conditions in the area are excellent because of abundant gas resources and a fine reasonable combination of the reservoir and structural settings with the oil & gas migration and preservation conditions, therefore this area is fully qualified for forming large-sized gas fields. Especially, the Jiuzhou-Gu'an structural belt should be the more realistic exploration territory owing to low exploration degree and existent several beneficial structures.

SUBJECT HEADINGS: Langfang Seg, Gu'an Seg, Natural gas, Oil and gas origin, Reservoir formation condition, Reservoir formation model

Zhang Yiming *(senior engineer)*, born in 1959, graduated from the Southwest Petroleum Institute in 1982 and received his Master's degree in 1990. Now he is engaged in the management and synthetic study. He won five provincial or ministerial achievement prizes and published more than ten articles.
Add: Renqiu, Hebei (062552), China Tel: (0317) 2721823

……

RESEARCH ON THE FRACTAL CHARACTERISTICS OF RESERVOIR MICRO HETEROGENEITY

Li Yunsheng (University of Electronic Science and Technology), Deng Hongbin (Research Institute of Exploration and Development, Southwest Oil and Gas Field Branch, PCL) and Lu Guoxiang (Southwest Petroleum Institute). *NATUR. GAS IND.* v. 22, no. 1, pp. 37 ~ 40, 1/25/2002. (ISSN1000 – 0976; **In Chinese**)

ABSTRACT: Reservoir micro pore structure is an important factor influencing reservoir porosity and permeability. In light of many studies it is shown that the reservoir micro pore structure is possessed of fractal characteristics. Because such a micro structure can't be identified easily with naked syes, a thorough research on reservoir micro heterogeneity is always difficult to carry out. Combined the PIA technique with fractal theory, a new fractal analysis method was obtained on the basis of the "Box Counthing" method. New method is very simple, easy and not affected by artificial factors. 16 sandstone and 2 carbonate rock thin sections collected from three wells in a certain oil field were analyzed by use of the new method. The analyzed results show that this method is superior to the traditional ones in characterizing the reservoir micro pore structure heterogeneity.

SUBJECT HEADINGS: Reservoir, Microstructure, Heterogeneity, Rock pore, Fractal, Image analysis

Li Yunsheng *(Doctor)*, born in 1969, graduated in petroleum engineering at the Southwest Petroleum Institute, being mainly engaged in the research on log signal processing and reservoir description. Now he is a postdoctoral student in the University of Electronic Science and Technology, mainly studying signal processing. He published several articles. Add: Chengdu, Sichuan (610054), China Tel: (028) 3252302

……

DEVELOPMENT OF DOWNHOLE CLOSED-LOOP VARIABLE-GAUGE STABILIZER

Yu Zhiqing and Fan Zhengxiang (Xi'an Petroleum Institute). *NATUR. GAS IND.* v. 22, no. 1, pp. 40 ~ 42, 1/25/2002. (ISSN1000 – 0976; **In Chinese**)

ABSTRACT: The downhole closed-loop control technique of well trajectory is an advanced technique followed with interest by domestic and foreign drilling circles, even by all the petroleum circles. Its successful development marked a revolution in drilling technology. Since the 1990's, owing to economic reason, extended-reach wells have been first considered to be used for developing the beach and offshore oil and gas fields and downhole closed-loop variable-gauge stabilizer is the key of solving these problems, which are found in the extended-reach wells at present, such as how to exert weight on bit effectively, overcome frictional resistance and raise drilling speed, stc. The structure, working principle and well trajectory control method of the variable-gauge stabilizer are introduced in the paper, thus providing an effective way for solving the problem children of extended-reach wells, especially for raising drilling speed and reducing drilling cost in beach and offshore oil and gas exploration in China.

SUBJECT HEADINGS: Extended-reach well, Variable-gauge stabilizer, Downhole closed-loop, Control

Yu Zhiqing *(Doctor)*, bon in 1964, graduated in petroleum engineering at the Moscow University of Petroleum Science and Technology and received his Doctor's degree in 1993. Now he is engaged in teaching and scientific research. He published two