西南石油大学学报(自然科学版)
2011年2月 第33卷 第1期
Journal of Southwest Petroleum University(Science & Technology Edition)
Feb. 2011 Vol.33 No.1
编辑部网址：http://www.swpuxb.com

文章编号：1674－5086(2011)01－0021－04
DOI：10.3863/j.issn.1674－5086.2011.01.004
中图分类号：TE121.2
文献标识码：A

综合多种方法识别济阳拗陷反转构造*

刘见宝[1,2]，夏 斌[1]，吕宝凤[1]，袁亚娟[1,2]，施秋华[1,2]
1. 中国科学院广州地球化学研究所，广东 广州 510640；2. 中国科学院研究生院，北京 石景山 100049

摘 要：陆相断陷湖盆陡坡带常发育多种砂体，由于其地震反射特征的特殊性，干扰了反转构造的识别。结合孤北洼陷五号桩断层带正反转褶皱和高青地区高青—平南断层正反转构造实例，分析了反转构造的地震反射特征，运用钻井资料进行地层细分和对比，声波时差进行剥蚀量的计算，流体包裹体的性质判断构造应力性质。五号桩断层带正反转褶皱地震反射特征呈现上凸下凹的外形，上部地层中间厚、两翼薄，且褶皱顶部遭受剥蚀，同相轴削蚀现象明显，下部地层保留了断陷盆地沉积充填特征；钻井资料亦显示背斜核部遭受剥蚀；声波时差随深度变化的关系曲线在剥蚀段明显错开。高青—平南断层发现了表征张性和压性环境的两类包裹体。多种方法相互约束可提高反转构造识别的准确率。

关键词：反转构造；声波时差；流体包裹体；济阳拗陷；地震反射特征

优先数字出版网址：http://www.cnki.net/kcms/detail/51.1718.TE.20110111.1016.005.html
刘见宝，夏 斌，吕宝凤，等. 综合多种方法识别济阳拗陷反转构造[J]. 西南石油大学学报：自然科学版，2011，33(1)：21～24.

引 言

与世界其他各大板块不同，中国大陆板块是由诸多小板块经历了多期构造旋回后拼合而成的。在这个极其复杂的大地构造背景下，我国含油气盆地的构造特征也相当复杂，大多是经历过构造反转的复合盆地，反转构造普遍发育，因此在我国含油气盆地中反转构造的研究尤为重要。前人对反转构造的形态、分类、形成机理及其对油气成藏的影响等方面做过诸多研究[1－8]，本文主要针对陆相断陷盆地陡坡带的构造、沉积特征，探讨反转构造的识别。

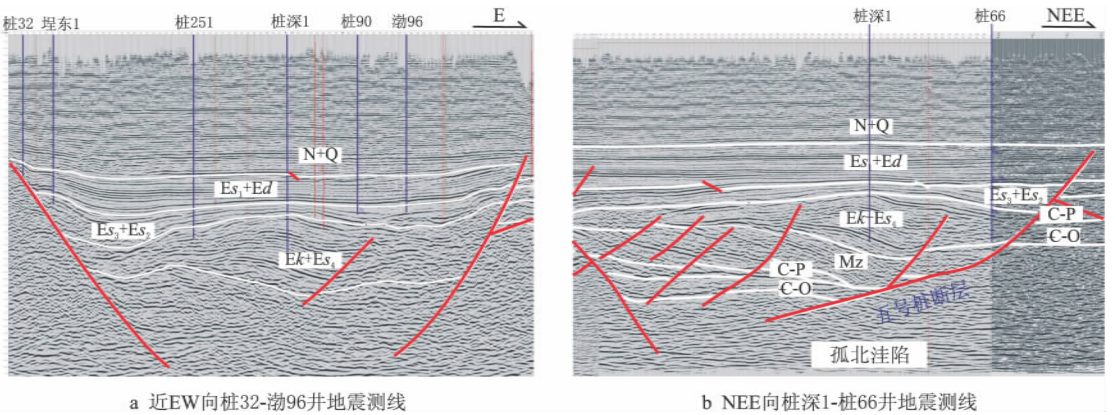
陆相断陷盆地陡坡带因为坡度陡、距物源近、古地形起伏大和构造活动强烈等原因，常常发育有多种成因的砂砾岩扇体，如冲积扇、近岸水下扇、扇三角洲、近源浊积扇等，这些砂砾岩扇体在地震剖面上形态和反射特征特殊，如冲积扇在倾向方向的地震剖面上形态常为楔形，内部反射杂乱或无反射，而且由于冲积扇主要由砂砾岩沉积物组成，一般具有较高的地震波传播速度，与以泥岩为主的湖相沉积地层相比，它与基底地层之间的波阻抗差较小，从而导致扇体之下的基底反射振幅变弱并呈同相轴上拉现象，由此多个冲积扇垂向叠置时，就会产生下伏早期冲积扇顶部同相轴遭受剥蚀的假象；近岸水下扇在重力滑动作用下，扇体常常发育构造明显的滚动背斜；近源浊积扇通常以“底平顶凸”的外形为特征，底部同相轴相对连续，顶部同相轴上凸，呈沙丘状，在与物源方向一致的地震剖面上通常呈楔状，当厚度较大时，其顶面往往形成上覆地层的披盖反射[9－11]。由于这些砂砾岩扇体的存在，干扰了反转构造的识别，因此很有必要综合多种方法识别反转构造。分别以孤北洼陷五号桩断层带正反转褶皱和高青地区高青—平南断层正反转构造为例，从地震反射、钻井资料、声波时差及包裹体特征4个方面论述反转构造的特征，为综合多种方法识别反转构造提供借鉴。

1 反转构造的地震反射特征

以孤北洼陷桩深1井区始新世沙四末期下凹上

* 收稿日期：2009－12－12 数字出版日期：2011－01－11
作者简介：刘见宝(1982－)，男(汉族)，河南开封人，博士研究生，主要从事石油地质方面的研究。E－mail:514348839@qq.com

凸型正反转褶皱为例。该正反转褶皱位于沾化凹陷孤北洼陷五号桩断层和埕东断层之间,在近 EW 向的桩 32 – 桩深 1 – 渤 96 井地震测线(图 1a) 和 NEE 向的桩深 1 – 桩 66 井地震测线(图 1b) 上均表现明显,古新统孔店组—始新统沙四段整体呈现中间厚、两翼薄的形态特征,其上部为一背斜形态、下部为一宽缓向斜形态,轴面均近于直立。就其内部特征而言,顶部地层遭受了一定程度的剥蚀,尤以桩深 1 井所在的背斜核部剥蚀强烈,同相轴削蚀现象明显,向两翼逐渐减弱; 而下部地层表现为典型的断陷盆地沉积充填特征。不整合面上,沙三段地层由背斜两翼向核部超覆,说明该反转构造形成于始新世沙四末期,裂陷期层序呈现出下凹上凸的透镜状外部形态,故可以称之为下凹上凸的褶皱型正反转[12 – 16]。



a 近EW向桩32-渤96井地震测线　　b NEE向桩深1-桩66井地震测线

图 1　不同方向地震测线显示孤北洼陷正反转褶皱

Fig. 1　Seismic lines in different directions shows positive inversion fold in Gubei Sag

2　反转构造的钻井资料特征

分别选取了位于该背斜核部的桩深 1 井和两翼的桩 839 井、桩 100 井对始新统沙四上亚段进行了地层细分和对比,图 2 表明,与桩 839 井和桩 100 井相比,桩深 1 井始新统沙四上亚段顶部缺失了层序 3。

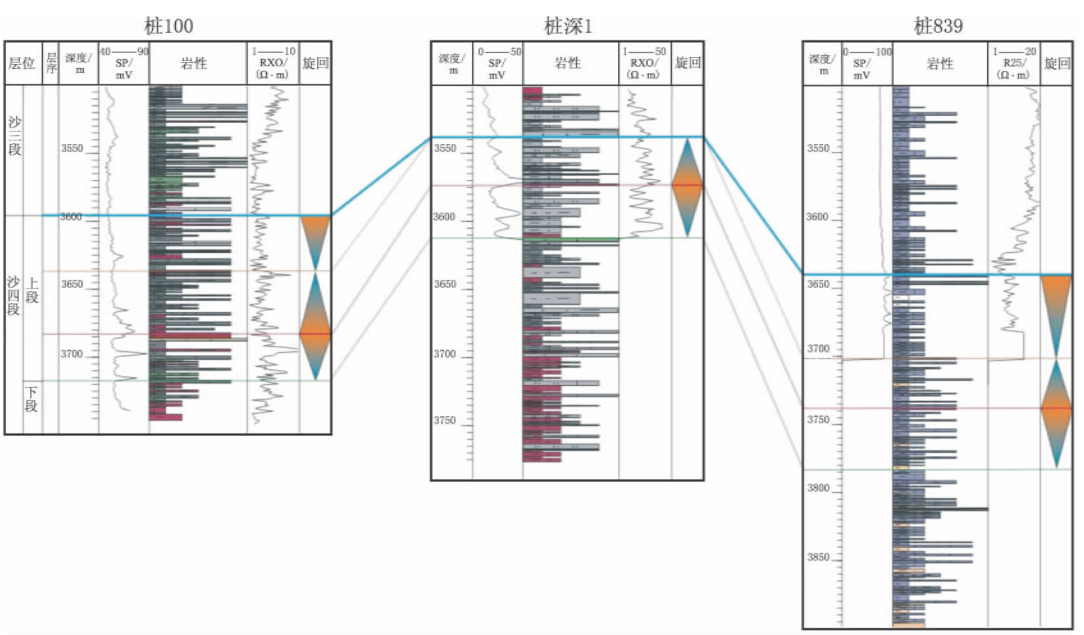


图 2　孤北洼陷桩 100 – 桩深 1 – 桩 839 连井地层对比图

Fig. 2　Stratigraphic correlation diagram of Zhuang 100 – Zhuang shen 1 – Zhuang 839 wells in Gubei Sag

3　反转构造的声波时差特征

进一步研究桩深 1 井的声波时差随深度变化的关系曲线可以发现(图 3) ,该井始新统沙四段与上覆沙三—沙二段曲线明显错开,表明沙四段顶部曾遭受过一定程度的地层剥蚀[17-21],由此可以推测桩深 1 井沙四段顶部缺失的层序 3 应为后期挤压抬升剥蚀作用所致,而非沉积缺失,故可以证明该地区在后期曾发生过褶皱隆升剥蚀,即始新世沙四末的正反转褶皱。

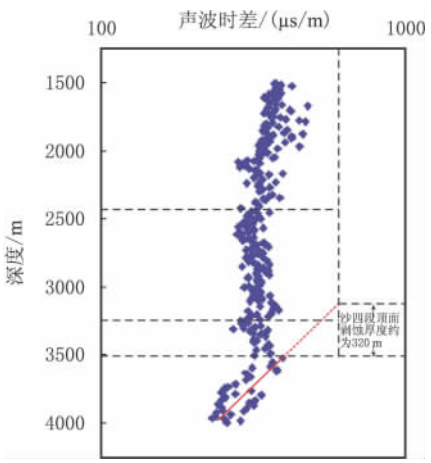


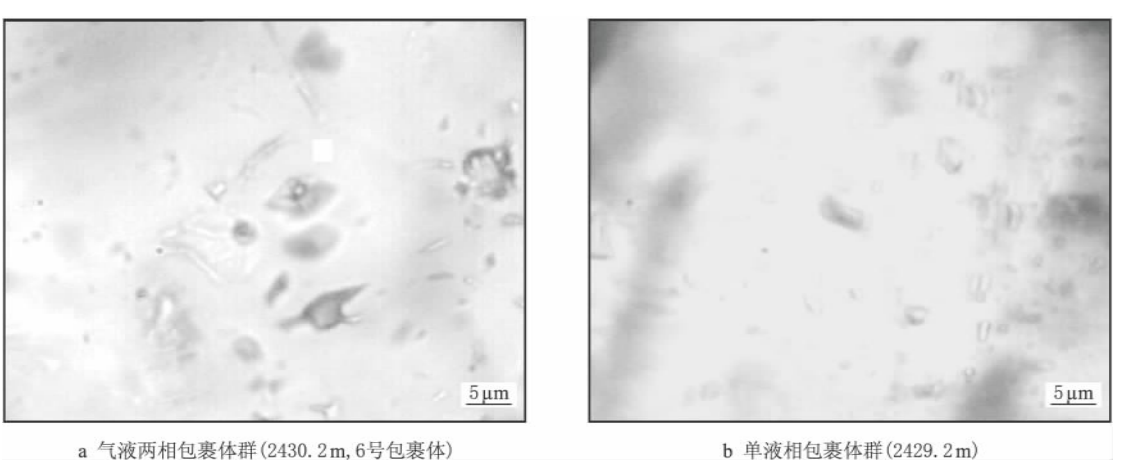
图 3　泥岩声波时差法计算桩深 1 井始新统沙四段顶部地层剥蚀量

Fig. 3　Calculate amount of Es_4 erosion of Zhuang shen 1 well by acoustic time

4　反转构造的包裹体特征

由于不同力学性质的断裂带内元素迁移不一样,而且与系统外交换的程度也不一样,因而可利用包裹体的 CO_2/H_2O 比值、粒度、相态、形态特征等分析断裂的力学性质。杨巍然等[22-23]对脆、韧性构造岩中的流体包裹体的研究认为,流体包裹体成分,特别是 CO_2/H_2O 的比值,可作为判断断裂力学性质和应变强度的依据。压性及压扭性应力形成的高应变韧性变形所形成的包裹体中 CO_2 含量高,而张性、张剪性应力所产生的低应变脆性变形的流体包裹体中 H_2O 含量高。

地震资料及钻井资料分析认为,济阳拗陷高青地区高青—平南断层东营末发育单一断展型正反转。对钻遇高青—平南断层的滨古 26 井进行了系统取样,所取样品为断层带及其上、下两盘岩芯样品,由于方解石脉记录了断层的活动历史,因此流体包裹体试样主要是取自方解石脉。在断层上、下 2 428.1 ~ 2 440.6 m 井段共取样磨片 9 块,多数样品中均出现方解石脉充填,包裹体含量十分丰富。在观察到的包裹体中,发现了原生的气相、气液两相包裹体,含量丰富,且直径一般较大,多在 3 ~ 8 μm(图 4a) ,气液两相包裹体气液比变化较大,这些特征被认为是张性断裂中发育的流体包裹体特征; 同时还发现了单相的(多为液相) 成定向排列的次生包裹体,其直径都比较小,多数在3 μm以下(图4b) ,均一温度较高,这些特征被认为是压性断裂中发育的流体包裹体特征。由此可以推测高青—平南断层形成以后,应该经历过不同时期、不同程度的构造反转。



a 气液两相包裹体群(2430.2 m, 6号包裹体)　　b 单液相包裹体群(2429.2 m)

图 4　高青—平南断层带内滨古 62 井的流体包裹体显微特征

Fig. 4　Microscopic characteristics of fluid inclusions of Bingu 62 well in Gaoqing-pingnan faults

5 结 语

陆相断陷湖盆陡坡带砂体发育,干扰了反转构造的正确识别,单纯从地震反射外形上判断反转构造可能会得出错误的结论。结合地震反射特征、钻井资料、声波时差及流体包裹体性质进行综合分析,相互约束,相互验证,可以提高反转构造识别的正确率。

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the analysis of the main diagenesis, also has the analysis of the strong and weak order of the main diagenesis. According to the optical thin section study, core observation and the research of uni-factor diagenetic facies, the paper divides the diagenetic facies in T_3x_2 Segment reservoir into 7 types, and researches the synthetical diagenetic facies in the T_3x_2 Section reservoir in Sichuan Basin. The research result indicates that the developmental condition of the T_3x_2 reservoir is centralized relatively, and the reservoir develops well in the middle of the basin, and develops badly in the edge and the east area of Sichuan Basin. Therefore, the part of the middle and the west area of Sichuan Basin is the range of profitability in the exploration and development in T_3x_2 Section reservoir.

Key words: Sichuan Basin; T_3x_2 reservoir; tight sandstone reservoir; diagenesis type; diagenetic facies

STUDY ON THE SEQUENCE STRATIGRAPHY AND DEPOSITIONAL SYSTEM OF DONGHE SANDSTONE IN TABEI UPLIFT

CHU Cheng-lin[1], LIN Chang-song[1], ZHU yong-feng[2], LIU Jing-yan[1], RUI Zhifeng[1] (1. School of Energy Resources, China University of Geosciences, Haidian Beijing 100083, China; 2. Tarim Oilfield Branch Company, CNPC, Korla, Xinjiang 841000, China) *JOURNAL OF SOUTHWEST PETROLEUM UNIVERSITY* (*SCIENCE & TECHNOLOGY EDITION*), *VOL.* 33, *NO.* 1, 15 - 20, 2011 (ISSN 1674-5086, in Chinese)

Abstract: Based on the outcrop, borehole, logging and seismic data, the Donghe Sandstone in Tabei Uplift is defined as a third-sequence stratigraphy. This sequence has an obvious sedimentary cycle from transgression to regression, and can be divided into transgressive system tract and highstand system tract. The major lithology of the Donghe Sandstone is detritus quartz sandstone which has a high composition and texture maturity. It develops cross bedding, parallel bedding, swash bedding, massive bedding and bioturbate structure. According to the progradational seismic facies and the core observation, wave-dominated delta depositional system is developed in well Donghe 20, Saike Uplift and well Cao 4.

Key words: Donghe Sandstone; sedimentary facies; wave-dominated delta; Tabei Uplift; sequence stratigraphy

TO IDENTIFY THE INVERSION STRUCTURES IN JIYANG DEPRESSION WITH INTEGRATED METHODS

LIU Jian-bao[1,2], XIA Bin[1], LV Bao-feng[1], YUAN Ya-juan[1,2], SHI Qiu-hua[1,2] (1. Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou Guangdong 510640, China; 2. Graduate University of China Academy of Sciences, Shijingshan Beijing 100049, China) *JOURNAL OF SOUTHWEST PETROLEUM UNIVERSITY* (*SCIENCE & TECHNOLOGY EDITION*), *VOL.* 33, *NO.* 1, 21 - 24, 2011 (ISSN 1674-5086, in Chinese)

Abstract: Steep slope of continental rift lake basin always develops a variety of sand bodies. They interfere with inversion structure recognition because of their particularity of seismic reflection characteristics. With examples of positive inversion folds of Wuhaozhuang fault zone in Gubei Sag and Gaoqing-Pingnan positive inversion fault in Gaoqing are-

as, the paper analyzes the seismic reflection characteristics of the inversion structure and formation subdivision and correlation with drilling data. The amount of erosion is calculated by acoustic time and tectonic stress characters are determined by fluid inclusions. The seismic reflection characteristics of positive inversion fold appear on the concave-convex shape in Wuhaozhuang fault zone, and the upper strata are thick in middle, thin in wings. The top of the fold suffers erosion, and reflection events cut significantly. The lower strata preserve filling characteristics of rift basin. Drilling data also show that the anticline core is denuded and acoustic time curve changes significantly in the denuded segment. Two types of inclusions developed in tensional and pressure environment in Gaoqing-Pingnan faults are found. The accuracy of inversion structure recognition is raised with a variety of mutually constraint methods.

Key words: inversion tectonics; acoustic time; fluid inclusions; Jiyang Depression; seismic reflection characteristics

MAIN CONTROLLING FACTORS ANALYSIS OF LOW PERMEABLE TIGHT RESERVOIRS OF CHANG 8 FORMATION IN ZHENJING AREA

DING Xiao-qi, ZHANG Shao-nan, XIE Shi-wen, Yi Chao(State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chendu Sichuan 610059, China) *JOURNAL OF SOUTHWEST PETROLEUM UNIVERSITY(SCIENCE & TECHNOLOGY EDITION)*, *VOL.* 33, *NO.* 1, 25 - 30, 2011(ISSN 1674-5086, in Chinese)

Abstract: Chang 8 Formation, Zhenjing area of southwest Ordos Basin is of low permeability, low abundance and rich reserves. Favorable petroleum exploration potential was displayed by many wells with high production which have been drilled in recent years. High qualities reservoirs are sheet sandstones bar in ascend hemicycle of middle period basal level cycles, and fractures with foundational faults can improve permeability of reservoirs extremely, and trend of fractures are northeast. Ferrocalcite cement of late lower cretaceous are controlled by fluctuations of lake floor shape, and weak ferrocalcite cement sandstone are distributed in ups of lake floor shape, and reservoir has fine physical property. Exploration idea and operating procedure of low permeable tight reservoirs of Chang 8 Formation are clarification on the sequence strata and high spots, tracking fractures and sedimentary facies.

Key words: Ordos Basin; Zhenjing area; Chang 8 Formation; low permeability; rules of hydrocarbon accumulation

SANDSTONE DIAGENESIS AND THE INFLUENCE FACTORS ON RESERVOIR OF XISHANYAO FORMATION IN YONGJIN AREA

ZHU Mei-heng[1], LI Mao-rong[2], ZHU Feng-yun[3], LI Yan-li[3](1. Geophysical Research Institute, Jianghan Oilfield, SINOPEC, Wuhan Hubei 430000, China; 2. Geological Scientific Research Institute, Shengli Oilfield Co. Ltd., SINOPEC, Dongying Shandong 257015, China; 3. Western New Prospect Research Center, Shengli Oilfield Co. Ltd., SINOPEC, Dongying Shandong 257015, China) *JOURNAL OF SOUTHWEST PETROLEUM UNIVERSITY(SCIENCE & TECHNOLOGY EDITION)*, *VOL.* 33, *NO.* 1, 31 - 36, 2011(ISSN 1674-5086, in Chinese)