

# 准噶尔盆地准中4区块侏罗系断裂特征 及对油气成藏的控制作用

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**内容提要:**准中4区块位于准噶尔盆地腹部, 油气资源丰富, 勘探潜力巨大, 但勘探程度低。结合断层几何学、运动学及动力学特征, 开展了侏罗系断层对油气藏控制作用的研究。结果表明: 研究区侏罗系以走滑断层为主, 构造样式有4种。D1井—D1井西区域以孤立或雁列式的中等角度逆断层为主, 部分正花状构造, 表现为早侏罗世拉张, 中晚侏罗世压扭; D2井北区域以负花状构造为主, 构造环境为张扭; D6井区域以直立缺少分支的走滑断层和负花状构造为主, 表现为早侏罗世拉张, 中晚侏罗世张扭。从时间上来说, 中侏罗世断裂平均活动速率最强, 早侏罗世次之, 晚侏罗世最弱。从区域上来说, D2井北区域在早中侏罗世断裂平均活动速率最大, 在晚侏罗世弱于D1井—D1井西区域, D6井区域在整个侏罗纪时期断裂平均活动速率最弱。同时, 探讨了油源断裂、断层相关圈闭、断层侧向封闭性对油气成藏的疏导、富集场所、聚集可能存在影响。

**关键词:**准中4区块; 侏罗系; 走滑断层; 断裂活动速率; 油气成藏

准中地区位于准噶尔盆地腹部, 现今呈南倾的大单斜构造背景(张功成等, 1999; 陈新等, 2002; 何登发等, 2005; 朱允辉等, 2005; 丁卫星, 2007)。中石化在准中地区共有四个已登记的区块, 分别为准中1区块、准中2区块、准中3区块、准中4区块。2002年于准中4区块部署的预探井D1井获得工业性油气流(宋岩等, 1997; 王英民等, 2002; 郭刚, 2014; 王锐, 2016), 证明该区块油气资源丰富, 勘探潜力大, 然而勘探程度较低。

准中4区块内共四块三维, 分别为D1井三维、D1井西三维、D2井北三维、D6井三维, 面积共1580 km<sup>2</sup>, 共完钻探井12口。目前的勘探工作主要集中在侏罗系, 以头屯河组和齐古组为主要的勘探目的层系。据宋传春(宋传春等, 2005; 贾庆素等, 2007; 李洪博等, 2009; 郭刚, 2014)等一些学者的研究, 准中地区中、新生代具有明显的负反转构造特征(张功成等, 1997; 褚庆忠, 2004; 何胜, 2012; 李涛等,

2015), 准中4区块中生代沉积时地层东倾, 新生代地层西倾, 高部位侏罗系加厚, 低部位侏罗系变薄, 呈明显的东西向负反转; 该区侏罗系构造层中主要发育有层间的正断层和逆断层, 断层延伸距离短, 一般为三级断层, 少有贯穿侏罗系、二叠系的大断裂, 侏罗系主要发育岩性圈闭或构造—岩性圈闭。但准中4区块断层较为复杂, 对于断层类型、构造样式、活动期次、成因、封闭性评价的相关研究较少, 断层与油气运聚成藏的关系不明。本文在三维地震断层精细解释、组合基础上, 通过断层构造样式, 断层分级、分类开展断层几何学特征研究, 通过平衡剖面制作, 断层活动速率统计, 不同时期、不同区域断裂差异性分析开展断层运动学及动力学特征分析, 结合油源、圈闭、封闭性探讨断层对油气藏的控制作用。该项研究不仅有利于指导该区侏罗系下一步油气勘探, 而且对于进一步深化断裂控藏理论有着重要的意义。

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# 1 地质背景

准噶尔盆地是我国西部四大含油气沉积盆地之一,位于新疆北部。盆地西北界为扎伊尔山、哈拉阿拉特山;东北界为阿尔泰山、青格里底山和克拉美丽山;南界为伊林黑比尔根山和博格达山。盆地面积约  $13 \times 10^4 \text{ km}^2$ ,发育石炭系—第四系沉积盖层,沉积岩最大厚度 15000 m(位于盆地南缘)(章若辉,2007;陈新发等,2008;陈建平等,2016)。准噶尔盆地是在古生代地体之上形成的以晚古生代—中、新生代陆相沉积为主的大型叠合盆地(钱志等,2009;邵雨等,2011),可划分为乌伦古坳陷、中央坳陷、陆梁隆起、东部隆起、西部隆起、北天山山前冲断带等七个一级构造单元。根据区域地质资料、较大的不整合和沉积演化特征可以将盆地划分为三个构造演化阶段,即:晚石炭世—二叠纪碰撞前陆盆地阶段、三叠纪—古近纪内陆拗陷盆地阶段和新近纪—第四纪再生前陆盆地阶段(宋岩等,2000;吴孔友等,2005;曲国胜等,2009)。准中4区块主体位于北天山山前坳陷内,广义上属于昌吉凹陷东端,狭义为阜康凹陷,向北延伸到白家海凸起的南部边缘,南邻北天山山前第三排构造带的阜康断裂带(张新见等,2012)(图1)。该区纵向上可划为下、中、上3个构

造层,3个构造层均具有南深北浅,向北逐渐抬升的特点(欧方军,2004)。目前该区勘探以侏罗系构造—岩性复合油气藏(隐蔽性油气藏)为主要勘探目标(李梅等,2012;刘传虎,2014)。侏罗系可进一步划分为下侏罗统八道湾组( $J_1b$ )、三工河组( $J_1s$ ),中侏罗统西山窑组( $J_2x$ )、头屯河组( $J_2t$ ),上侏罗统齐古组( $J_3q$ )。

# 2 断裂几何学特征

## 2.1 构造样式

概括的说,构造样式是同一时期构造变形或同一应力作用下所产生的构造的总和,它们具有相似或相同的构造特征和变形机理(罗小龙等,2012;崔营滨,2013)。在区域构造应力场研究基础上,通过对地震资料的精细层位与断层解释,结合相干属性(图2)、时间切片开展断层组合,划分断裂的类型,分析断裂形成的构造环境,总结断层构造样式。研究区侏罗系断层在剖面上表现为形态陡立,倾向忽左忽右,时正时逆;在平面上出现雁行式排列或平行排列,呈“X”型,具有丝带效应特征(秦峰,2013);在时间切片上明显发生同相轴有规律的错动,出现水平位移。据统计,本次研究区共解释及组合断层326条,大部分断层断开1~3个层位,断开整个侏罗

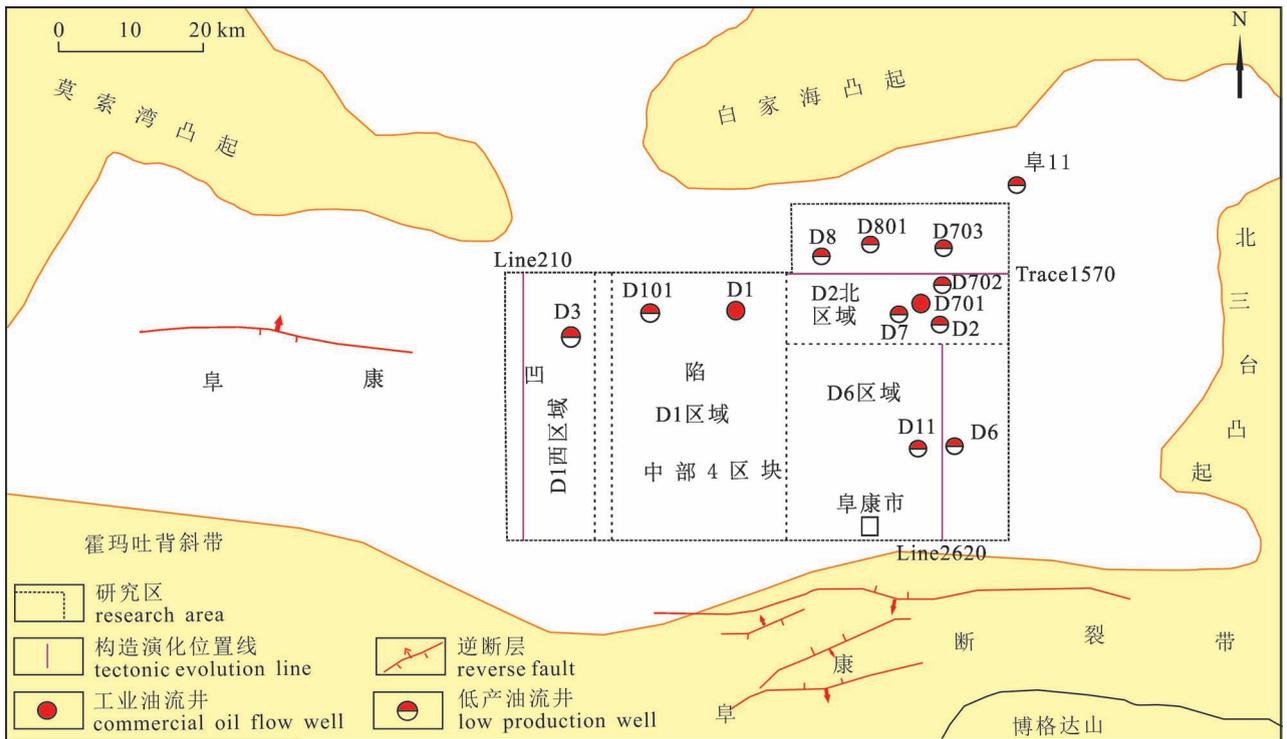


图1 准噶尔盆地准中4区块构造位置图(据张新见等,2012修改)

Fig. 1 Location of block 4 in the center of the Junggar Basin(modified from Zhang Xinjian et al.,2012&)

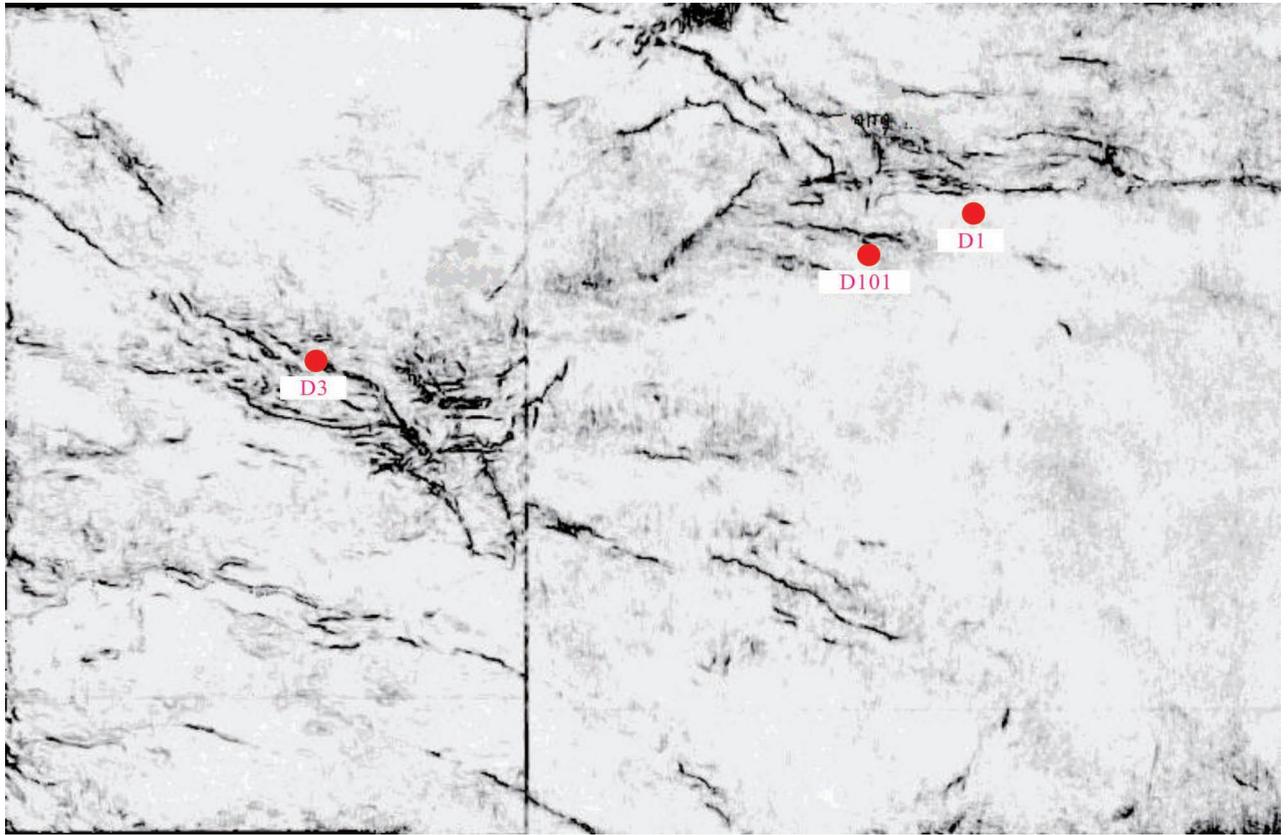


图 2 准噶尔盆地过 D1 井—D1 井西三维侏罗系相干平面图

Fig. 2 D1 and D1 west 3D seismic coherence plan of Jurassic

系的断裂极少,平面延伸距离短,大部分断层延伸距离 1 km,延伸距离超过 1.5 km 的断裂只有 1 条。总结出准中 4 区块发育 4 种断层构造样式,研究区所见断层主要为走滑断层,断层剖面几何样式上主要见花状构造(包括正花状与负花状),由一条主干断层和若干派生断层共同组成一个类似“花”的结构,主干断层倾角较陡,派生断层自浅向深汇集。另外也见到一些孤立或雁列式的中等角度逆断层和近直立的缺少分支断层的走滑断层(图 3)。

**正花状构造样式:**主干断层近直立,夹持部分形成隆起断块和背斜,它是压扭性断层作用的产物,其派生的分支断层是压扭性的,剖面上形成似地垒式构造。这种构造样式的断层在研究区内主要分布在 D2 井—D7 井—D1 井—D101 井一线,走向近东西向。

**负花状构造样式:**负花状构造是在具有转换拉伸作用的走滑断层上产生的一套凹面朝上的分支正断层系构成的地堑式构造,剖面上也呈花状组合特征,与正花状构造相对应。这种构造样式断层在研究区主要分布在 D8 井附近,断层走向近南北。

## 2.2 断裂分级、分类

### 2.2.1 断裂分级

根据断裂的规模、作用、分布规律及对油气的影响,一般情况下将断裂分为三级。一级断裂控制隆起的形成与演化;二级断裂控制构造带的分布与特征;三级断裂调节不同区段的构造变形,规模较小、数量多,对局部圈闭、油气藏有一定控制作用(邬光辉等,2012)。准中 4 区块位于准噶尔盆地腹部,侏罗系断层基本为三级断裂,断距不大,平面延伸短,对局部构造的发育有一定的制约关系。

### 2.2.2 断裂分类

在地震资料解释和断层组合的基础上对断裂的平面展布特征进行了分析。如图 4 所示:平面上正断层数量多于逆断层。逆断层主要集中于 D1 井—D1 井西区域,其次少量分布于 D2 井北区域;D6 井区域全部发育正断层。通过统计,其中正断层 207 条,占 63.50%,逆断层 119 条,占 36.50%。断层相互之间基本平行,呈羽状排列,存在一定程度的雁列式排列,部分断层存在交切关系。在此基础之上,对断裂走向、倾向进行了详细统计,统计结果如下:正

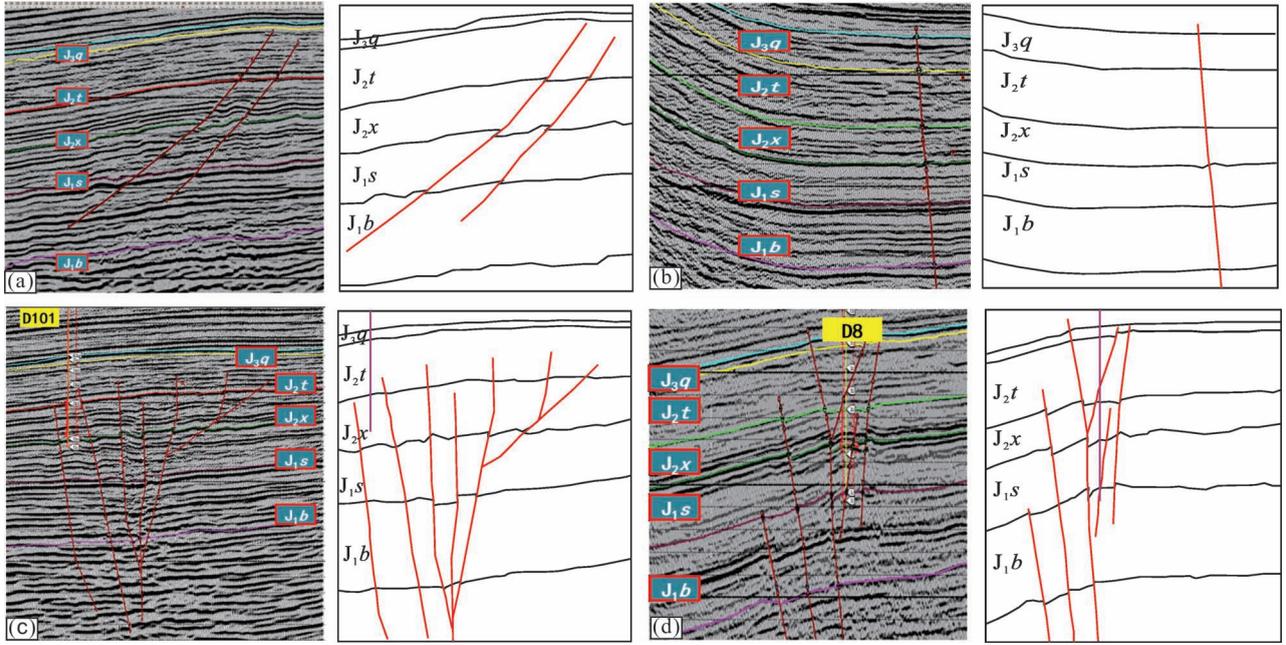


图3 准噶尔盆地准中4区块断层典型地震剖面及典型几何样式

Fig. 3 Typical seismic section and geometric patterns of fault of block 4 in the center of the Junggar Basin

(a) 孤立或雁列式的中等角度逆断层; (b) 近直立的缺少分支断层的走滑断层; (c) 正花状构造; (d) 负花状构造

(a) isolated or Echelon Middle angle reverse fault; (b) a up-right strike slip fault with a lack of branch faults;

(c) positive flower structure; (d) negative flower structure

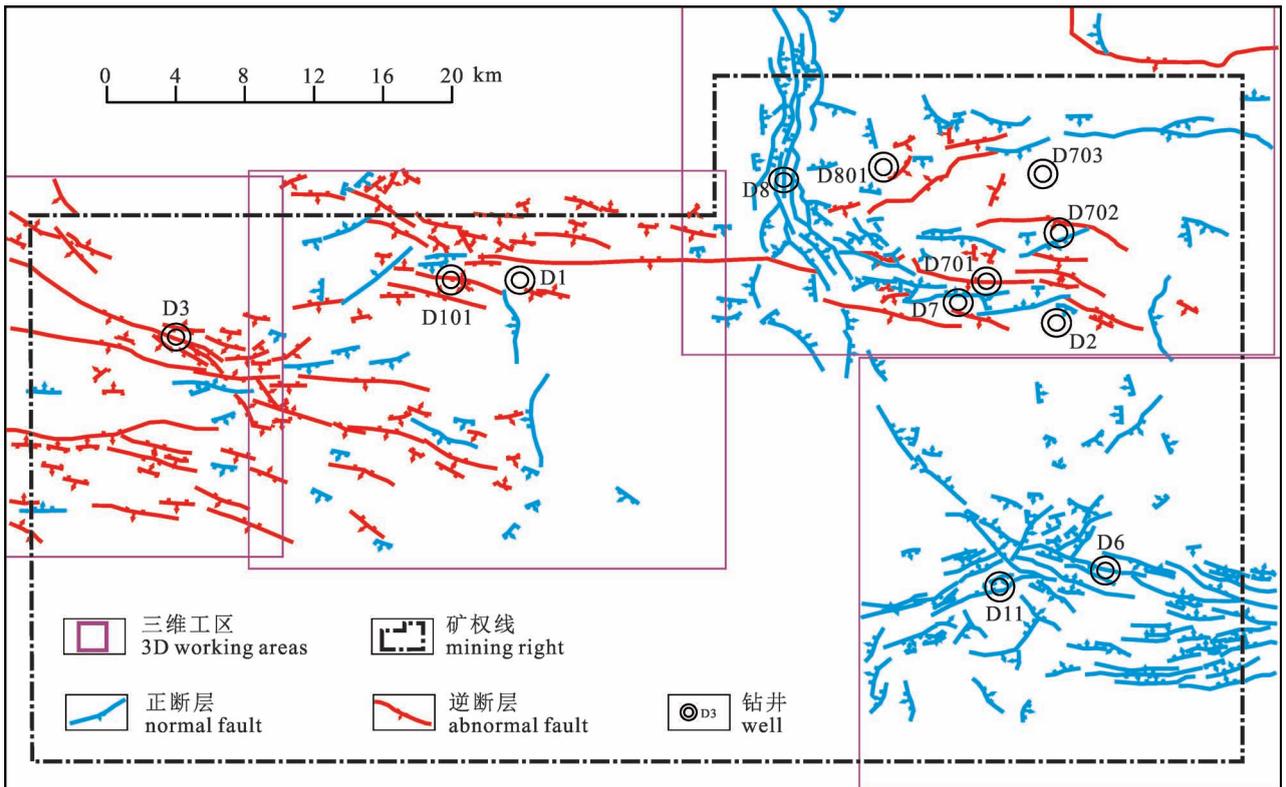


图4 准噶尔盆地准中4区块侏罗系断裂展布图

Fig. 4 Fault distribution of Jurassic of block 4 in the center of the Junggar Basin

断层基本上呈北西向和北东向展布,北西向共 104 条,北东向 103 条,共 207 条。北西向正断层中倾向南西 54 条,倾向北东 50 条;北东向正断层中倾向南东 55 条,倾向北西 48 条。表明正断层几乎不存在相对优势走向或者倾向。逆断层主要呈北西向和北东向。北西向共 95 条,北东向 24 条,共 119 条。北西向逆断层中倾向南西 63 条,倾向北东 32 条;北东向逆断层中倾向南东 18 条,倾向北西 6 条。表明逆断层以北西走向,倾向南西相对优势发育。

下侏罗统八道湾组上部砂、泥岩互层夹煤层,中部深灰色泥岩,下部砂砾岩及煤层,是研究区内一套较好的生油源岩(况昊,2012;张善文,2013)。头屯河组和齐古组原油来源于八道湾组,断至八道湾组的断层可作为油源断层。油气成藏与分布受八道湾组烃源岩生烃范围和油源断层控制,构造运动使断层开启,生烃增压,油气沿油源断层向上运移,是成藏的关键,共发生 2 期油气充注,成藏过程可分为 3 幕,距油源断层越近越容易成藏(郑金海等,2015;

刘振阳等,2017)。按是否能成为油源断层进行分类,工区内大部分断层均断至八道湾组(图 5),可以作为油源断层,为油气成藏提供疏导通道。

### 2.3 断裂分区差异对比

D1 井—D1 井西区域侏罗系断裂以逆断层为主,主要呈北西向展布,主要倾向南西,断距小,分析认为可能受莫索湾凸起影响,表现为一定的花状和雁列式,部分断层倾角大,具有压扭性质。

D2 井北区域侏罗系断裂可能受白家海走滑断裂和博格达山推覆带双重影响,既有正断层,也有逆断层,发育似负花状构造,正断层分布在北部,呈近南北向展布,逆断层分布在南部,呈近东西向展布,北东部发育层间断层。

D6 井区域侏罗系断裂可能受博格达山影响,均表现为正断层,以 D6 井为界,D6 井以东呈近东西向展布,D6 井以西呈北东—南西向和北西—南东向展布。断裂主要倾向正北、北东,少部分倾向正南、南西。

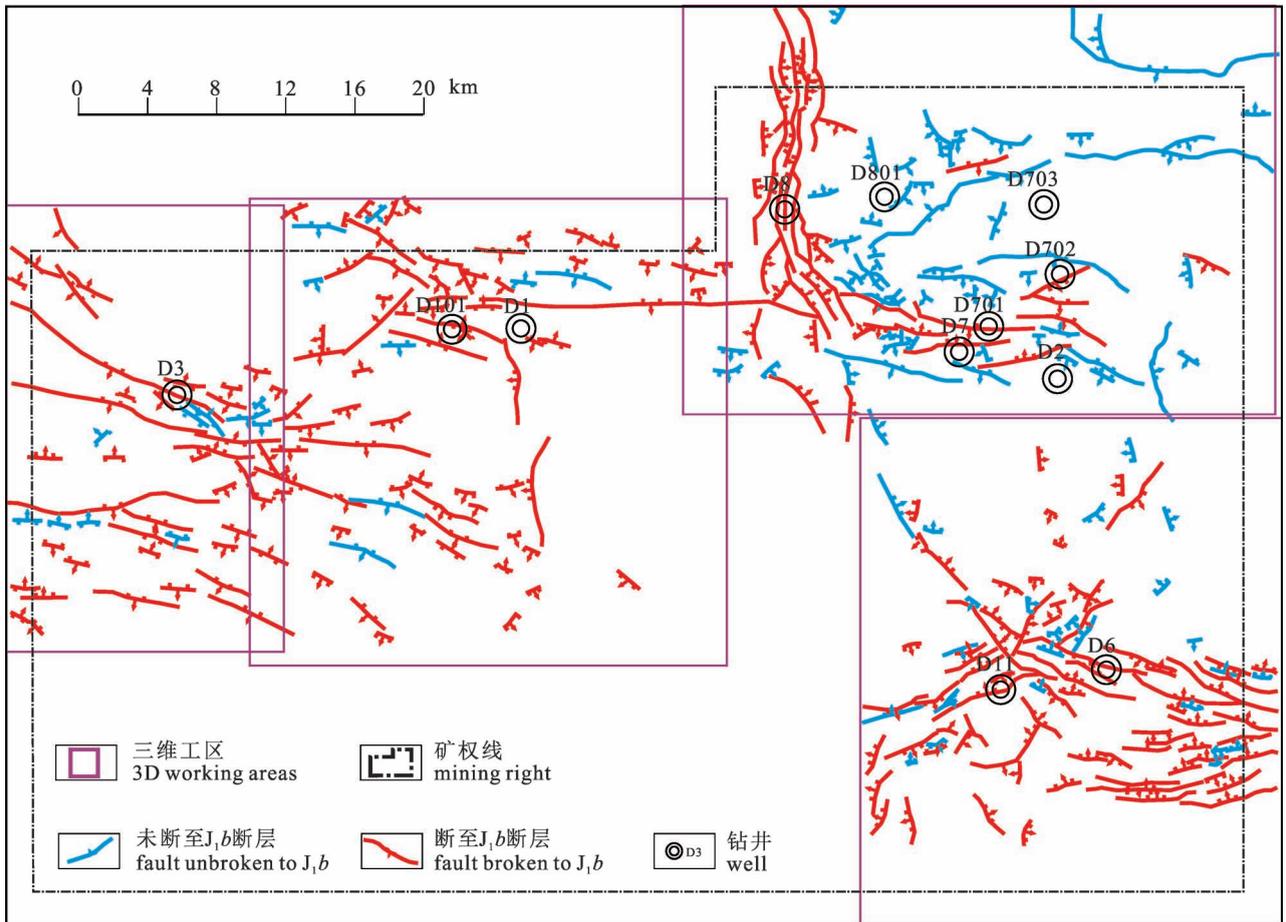


图 5 准噶尔盆地准中 4 区块侏罗系油源断层分布图

Fig. 5 Oil source fault distribution of Jurassic of block 4 of the center of the Junggar Basin

表1 准噶尔盆地准中4区块构造演化特征表

Table 1 Tectonic evolution table of block 4 in the center of Junggar Basin

| 区域         | 构造样式                     | 构造环境           |
|------------|--------------------------|----------------|
| D1井—D1井西区域 | 孤立或雁列式的中等角度逆断层为主,部分正花状构造 | 早侏罗世拉张,中晚侏罗世压扭 |
| D2井北区域     | 负花状构造为主                  | 张扭             |
| D6井区域      | 直立缺少分支的走滑断层和负花状构造为主      | 早侏罗世拉张,中晚侏罗世张扭 |

### 3 断裂运动学与动力学特征

本次准中4区块侏罗系断裂运动学特征研究主要通过平衡剖面技术,结合构造样式、断裂活动速率进行分析。通过构造演化获得相应时期断层活动的距离(单位:m)除以该时期持续的地质时间(单位:Ma)得到断裂活动速率(单位:m/Ma)。

#### 3.1 分区运动学特征

##### 3.1.1 D1井—D1井西区域断裂运动学特征

D1井—D1井西区域,现今以孤立或雁列式的中等角度逆断层为主,早侏罗世,拉张为主,表现为正断层,中晚侏罗世,压扭为主,表现为逆断层,通过构造活动速率统计,各断层各时期活动速率有差异,活动速率在1.23~6.84 m/Ma,整体上,中侏罗世西山窑期和头屯河期,断裂活动速率强,早侏罗世八道湾期和三工河期次之,晚侏罗世齐古期,断裂活动速率最弱(图6)。

##### 3.1.2 D2井北区域断裂运动学特征

D2井北区域,以负花状构造为主,在侏罗纪时期,构造环境表现为张扭。剖面上表现为一套凹面朝上的分支正断层系构成的地堑式构造。通过构造活动速率统计,各断层各时期活动速率存在差异,活动速率在1.36~9.50 m/Ma,中侏罗世西山窑期和头屯河期,断裂活动速率强,部分断层在中侏罗世活动达到6.02~9.50 m/Ma,早侏罗世八道湾期和三工河期次之,活动速率为1.76~5.01 m/Ma,晚侏罗世齐古期,断裂活动速率最弱,活动速率为1.36~2.09 m/Ma。(图7)

##### 3.1.3 D6井区域断裂运动学特征

D6井区域,以近于直立缺少分支的走滑断层和负花状构造为主,早侏罗世,表现为拉张,发育正断层,中晚侏罗世,以压扭为主,主要发育花状构造和缺少分支的近于直立断层。通过断裂活动速率统计,该区域整体断裂活动速率相对D1井—D1井西区域和D2井北区域而言较弱。断层各时期活动速率有差异,活动速率在0.80~6.99 m/Ma,中侏罗世西山窑期和头屯河期,断裂活动速率强,部分断层在

中侏罗世西山窑期和头屯河期活动速率分别为6.99 m/Ma和5.58 m/Ma,早侏罗世八道湾期和三工河期次之,活动速率为0.9~2.8 m/Ma,晚侏罗世齐古期,断裂活动速率最弱,活动速率为0.80~1.96 m/Ma(图8)。

#### 3.1.4 分区运动学特征差异性

在分区域断裂分析基础上,对准中4区块构造演化特征进行了总结,D1井—D1井西区域以孤立或雁列式的中等角度逆断层为主,部分正花状构造,构造环境为早侏罗世拉张,中晚侏罗世压扭;D2井北区域以负花状构造为主,构造环境张扭;D6井区域以直立缺少分支的走滑断层和负花状构造为主,构造环境为早侏罗世拉张,中晚侏罗世张扭(表1)。从分区来讲,D2井北区域在早中侏罗世断裂平均活动速率最大,晚侏罗世弱于D1井—D1井西区域。D6井区域在整个侏罗纪时期断裂平均活动速率最弱(图9)。

#### 3.2 分期运动学与动力学特征

研究区侏罗系断裂主要在中侏罗世形成的,有215条,占65.95%,在D1井—D1井西区域、D2井北区域及D6井区域均较为发育,受莫索湾凸起、白家海走滑断裂和博格达山共同影响;其次断裂形成时期为早侏罗世,有76条,占23.31%,主要分布在D6井区域,受博格达山影响,以拉张作用为主;晚侏罗世形成断层较少,只有35条,占10.74%,零星分布于研究区,主要受白家海走滑断裂的影响(图10)。本次研究对侏罗系各个时期断裂活动速率进行了分析(表2)。八道湾期,D2井北区域断裂活动速率最大,平均为2.66 m/Ma;D1井—D1井西区域断裂活动速率次之,平均为2.37 m/Ma;D6井区域断裂活动速率最小,平均为2.14 m/Ma。三工河期,D2井北区域断裂活动速率最大,平均为2.99 m/Ma;D1井—D1井西区域断裂活动速率次之,平均为1.79 m/Ma;D6井区域断裂活动速率最小,平均为1.45 m/Ma。西山窑期,D2井北区域断裂活动速率最大,平均为5.92 m/Ma;D1井—D1井西区域断裂活动速率次之,平均为5.28 m/Ma;D6井区域断

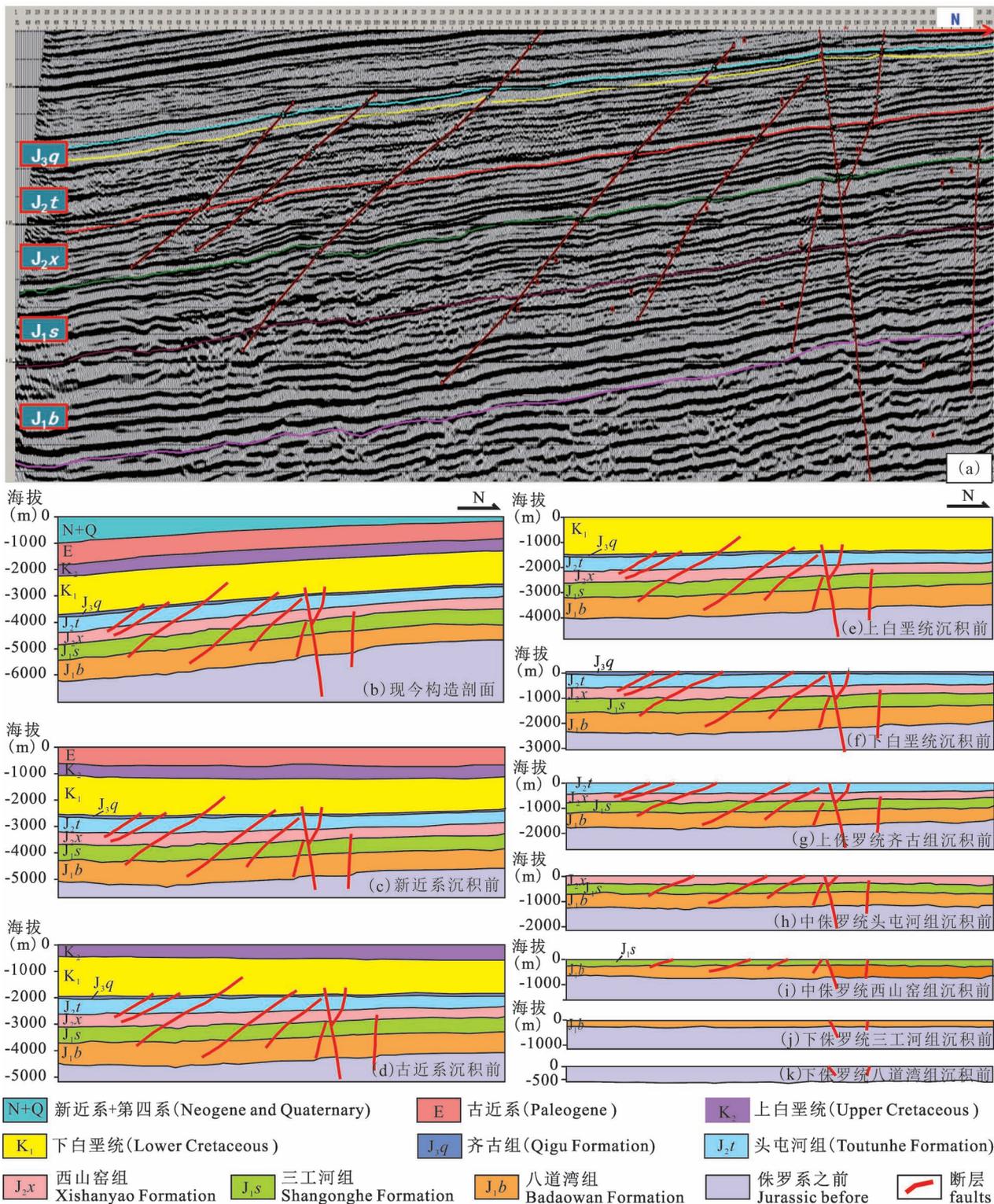


图 6 准噶尔盆地过 D1 井西三维 Line 210 测线地震解释及构造演化示意图 (地震测线位置见图 1)

Fig. 6 Seismic interpretation and tectonic evolution of D1 west 3D of the Line 210 (Seismic line located Fig. 1)

裂活动速率最小, 平均为 3.18 m/Ma。头屯河期, D2 井北区域断裂活动速率最大, 平均为 6.56 m/Ma; D1 井—D1 井西区域断裂活动速率次之, 平均

为 4.29 m/Ma; D6 井区域断裂活动速率最小, 平均为 3.32 m/Ma。齐古期, D1 井—D1 井西区域断裂活动速率最大, 平均为 1.94 m/Ma; D2 井北区域断

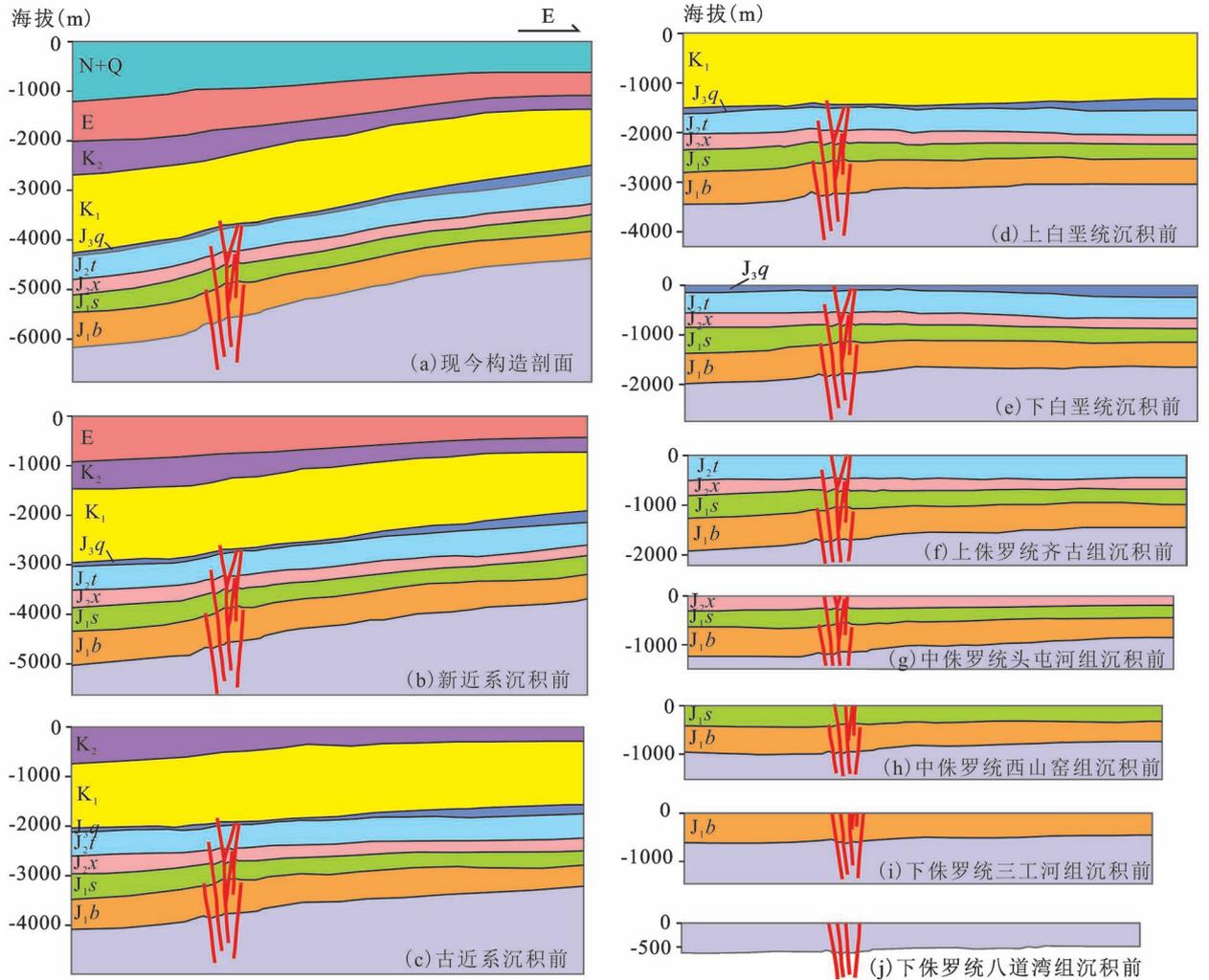
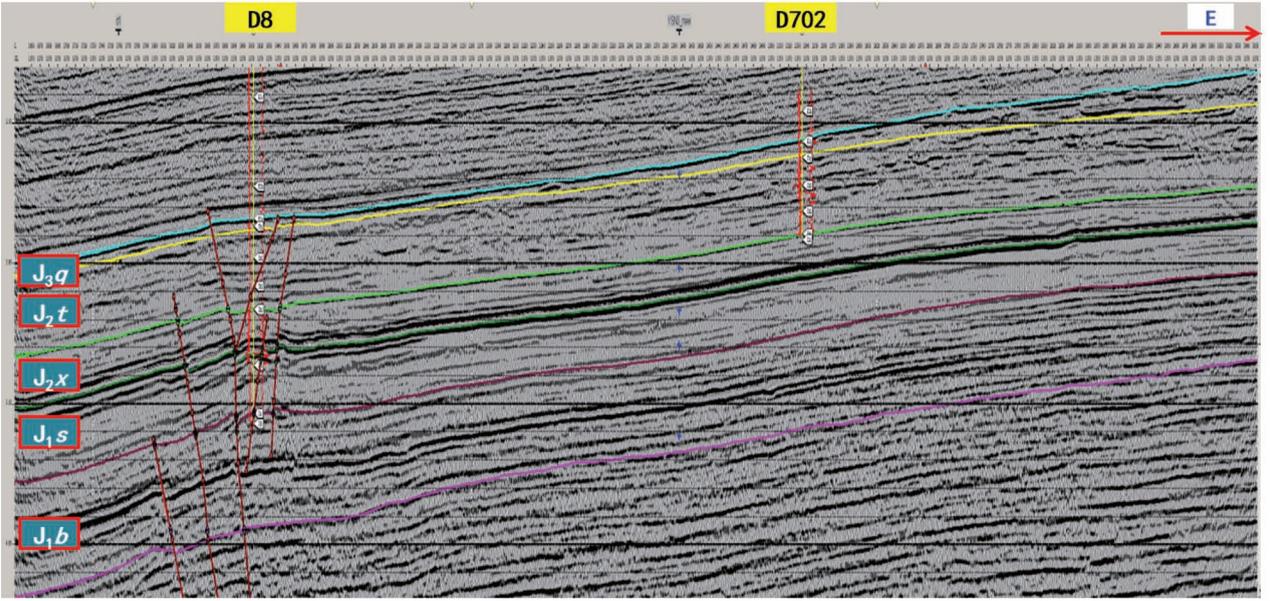


图7 准噶尔盆地过 D2 井北三维 Trace1570 线地震解释及构造演化示意图 (地震测线位置见图 1, 图例同图 6)

Fig. 7 Seismic interpretation and tectonic evolution of D2 north 3D of the Trace1570

(Seismic line located Fig. 1, Legend is the same as Fig. 6)

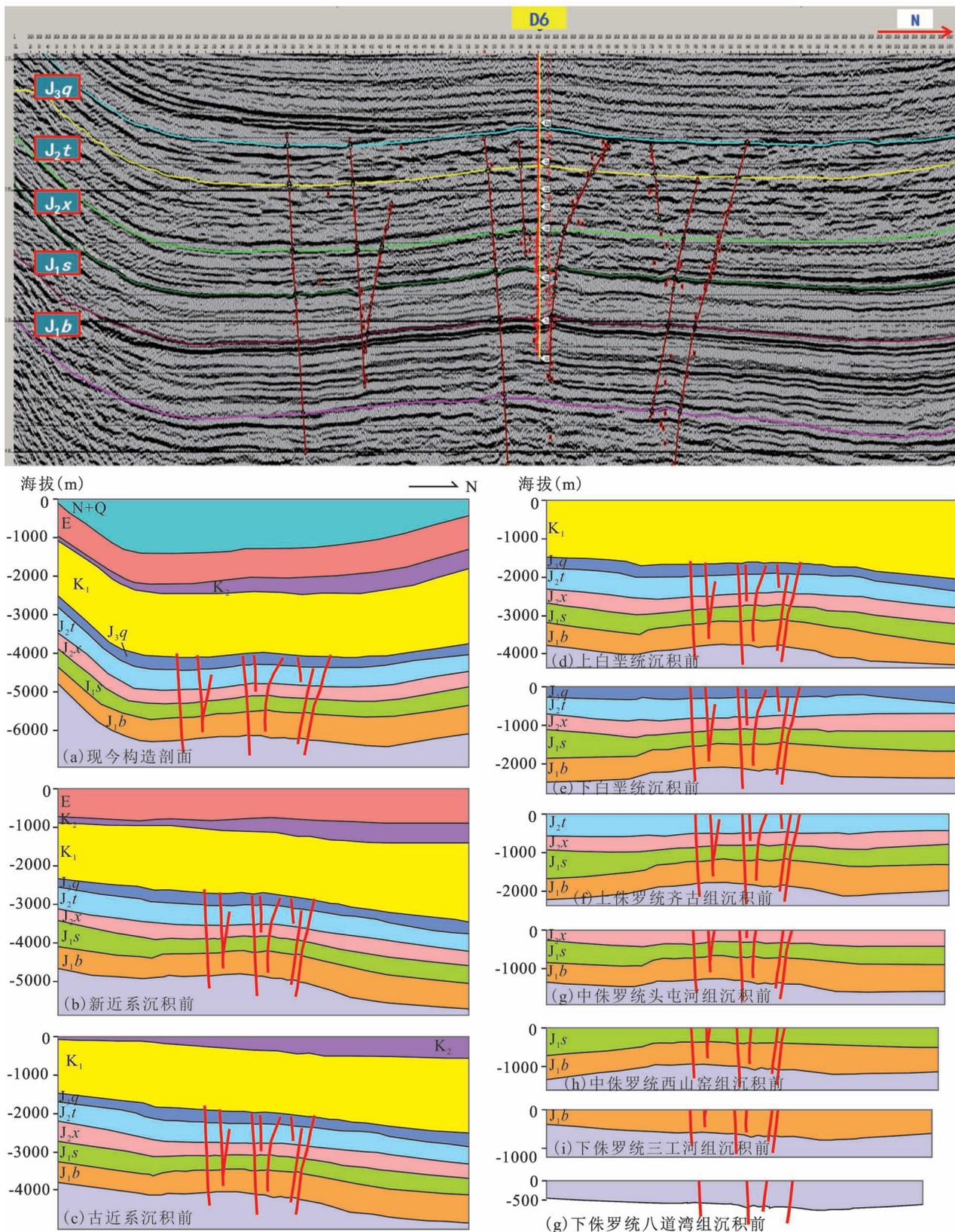


图 8 准噶尔盆地过 D6 井三维 Line2620 线地震解释及构造演化示意图 (地震测线位置见图 1, 图例同图 6)

Fig. 8 Seismic interpretation and tectonic evolution of D6 3D of the Line2620

(Seismic line located Fig. 1, Legend is the same as Fig. 6)

裂活动速率次之,平均为 1.65 m/Ma;D6 井区域断裂活动速率最小,平均为 1.25 m/Ma。整体上,中侏罗世断裂平均活动速率最强,早侏罗世次之,晚侏罗世最弱(图 11)。

表 2 准噶尔盆地准中 4 区块各区断裂平均活动速率统计表  
Table 2 The average rate of fault activity in various regions of the Jurassic of block 4 in the center of Junggar Basin

| 区域              | D1 井—D1 井西区域<br>(m/Ma) | D2 井北区域<br>(m/Ma) | D6 井区域<br>(m/Ma) |
|-----------------|------------------------|-------------------|------------------|
| J <sub>3q</sub> | 1.94                   | 1.65              | 1.25             |
| J <sub>2t</sub> | 4.29                   | 6.56              | 3.32             |
| J <sub>2x</sub> | 5.28                   | 5.92              | 3.18             |
| J <sub>1s</sub> | 1.79                   | 2.99              | 1.45             |
| J <sub>1b</sub> | 2.37                   | 2.66              | 2.14             |

侏罗系是准噶尔盆地振荡演化阶段的产物,早中侏罗世持续了晚三叠世的古构造格局,盆地处于区域伸展构造背景下的缓慢沉降时期(陈发景等,2000;陈建平等,1998;王素华等,1999)。中晚侏罗

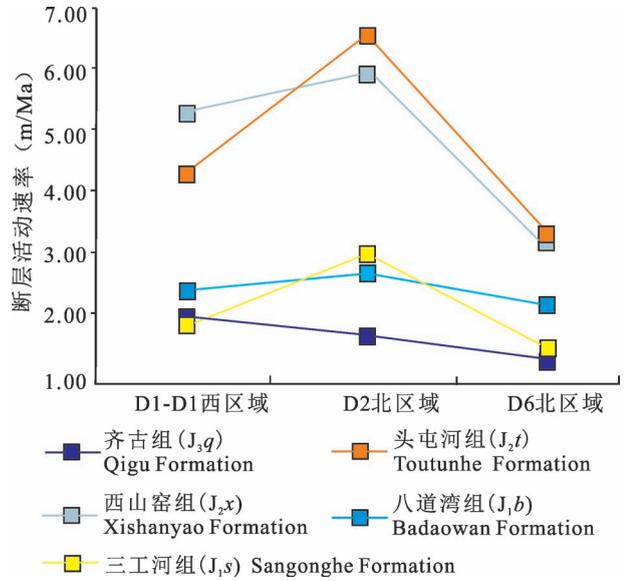


图 9 准噶尔盆地准中 4 区块侏罗系各区域断裂平均活动速率图

Fig. 9 The average fault activity rate in various regions of block 4 in the center of the Junggar Basin

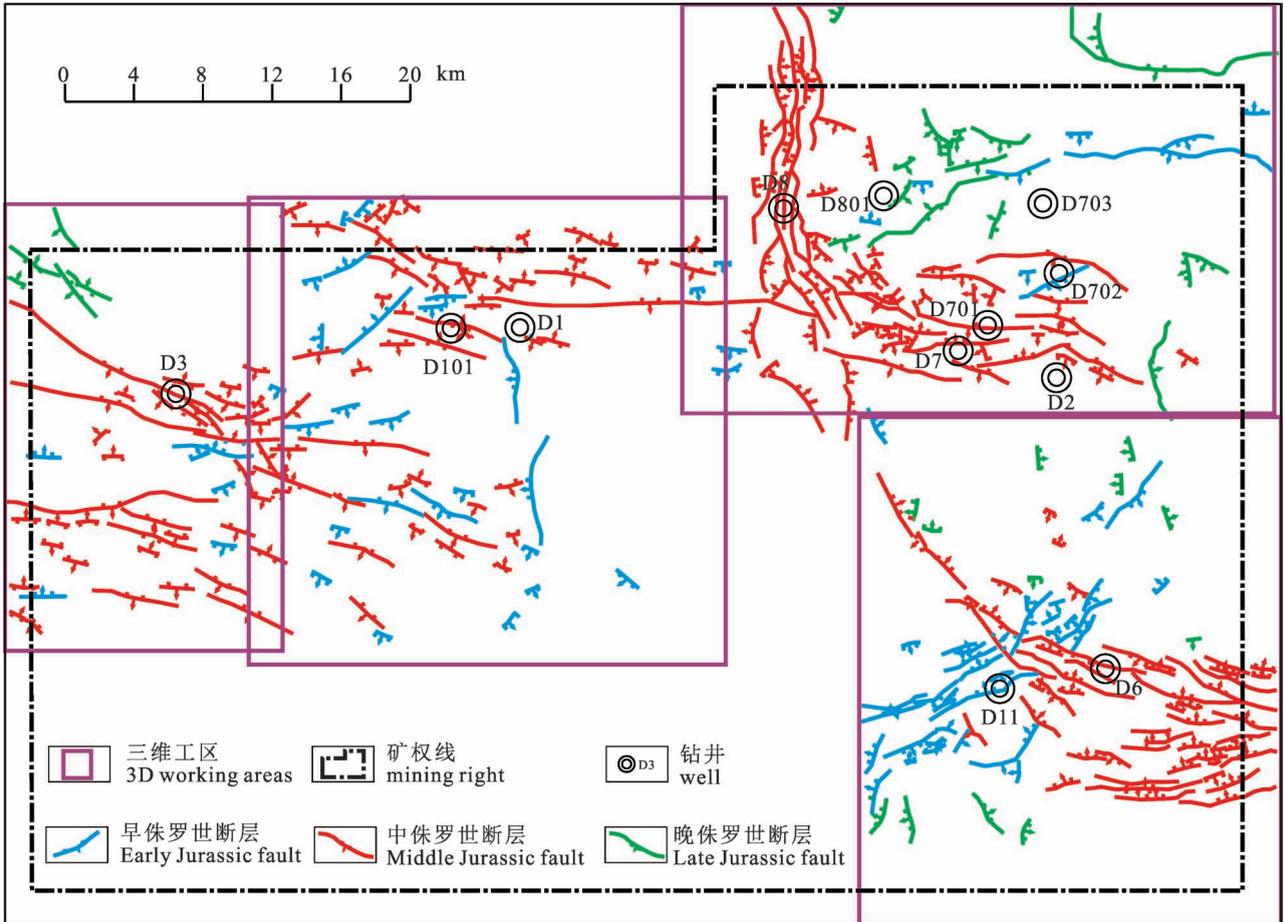


图 10 准噶尔盆地准中 4 区块侏罗分期断裂展布图

Fig. 10 Staging fault distribution of Jurassic of block 4 of the center of the Junggar Basin

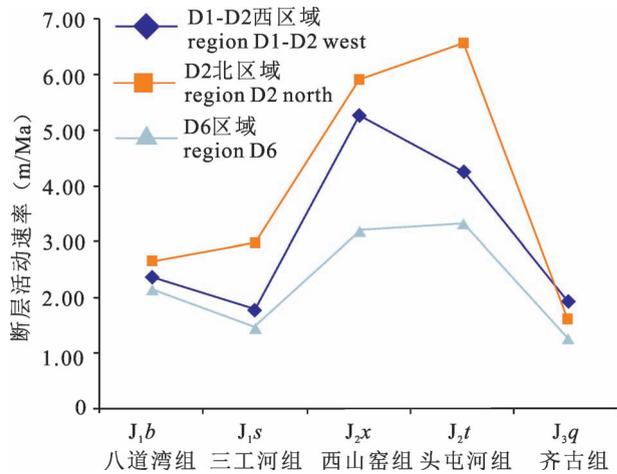


图 11 准噶尔盆地准中 4 区块侏罗系各时期断裂活动速率图

Fig. 11 The average fault activity rate in various periods of the Jurassic of block 4 in the center of the Junggar Basin

世,受燕山运动挤压作用的影响,使盆地腹部逐渐隆升,遭受剥蚀,形成了车排子—莫索湾低凸起(即车莫低凸起)。白垩纪—新近纪,盆地全面下沉改造,现今除莫索湾构造仍具有背斜形态外,盆地腹部总体呈一负向构造区(孙自明等,2004;郭刚,2014)。昌吉凹陷受燕山期博格达山古构造缓慢的隆升,东段表现为由南向北向盆地方向推挤的主应力,相反方向上,受莫索湾凸起和白家海凸起(二者均为二叠纪开始发育的古凸起)的阻挡,三个方向共同作用的区域产生挤压背景下复杂的扭性压力,由于这种压力的释放,在凸起的前端位置发育了花状断裂(孙自明等,2004;吴孔友等,2005)。D1 井—D1 井西区域、D2 井北区域及 D6 井区域由于所处的位置存在差异,D1 井—D1 井西区域离莫索湾凸起较近,可能受莫索湾凸起影响较大;D2 井北区域位于白家海凸起和博格达山之间,可能受白家海走滑断裂和博格达山推覆带双重影响,D6 井区域离博格达山较近,可能主要受博格达山影响。不同时期构造应力性质的不同以及位置的各异,造成了 D1 井—D1 井西区域、D2 井北区域及 D6 井区域断裂几何学和运动学的差异。

## 4 断层对油气成藏控制作用的探讨

### 4.1 油源断裂是否发育对油气富集条件存在影响

根据钻井油气显示级别与距油源断裂距离相关关系统计结果可知,油源断层附近油气显示丰富,级别高;远离油源断层,油气显示变差(图 12)。另外

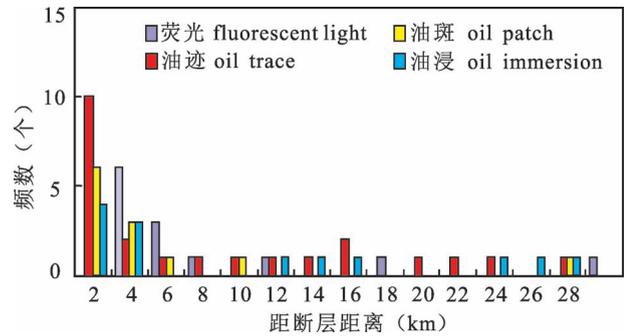


图 12 准噶尔盆地准中 4 区块侏罗系油气显示与距断层距离统计图

Fig. 12 Histogram of indication of oil and gas and distance from fault of the Jurassic of block 4 in the center of the Junggar Basin

从阜康凹陷东部斜坡及凸起带现今发现的油气及中 4 区块现今钻探情况来看,成功井和油气显示井多位于断层带附近,而没有油气显示的钻井多位于无断裂发育的地区,这说明该区油气的富集与断层密切相关,并受断层的控制。对于研究区 D2 井北区域,远离油源断裂的 D702 井、D703 井、D801 井几乎无油气显示,推测认为沟通油源的断裂或断裂组合可能是油气富集的首要条件,若没有断裂沟通油源,烃源岩生成的油气难以运移到头屯河组和齐古组内的砂体中。

### 4.2 与断层有关的圈闭类型影响油气富集场所

圈闭是油气聚集的场所和勘探目标(王川等,2006;杨国臣等,2008),在准噶尔盆地凸起及斜坡地带,断裂和砂体发育,圈闭往往易于识别,而在凹陷内部,圈闭多是隐蔽圈闭,难以识别。应用三维地震资料,对研究区内断裂进行识别,并对沉积相平面展布进行研究,二者结合,在研究区内主要识别了四类隐蔽的岩性圈闭或构造—岩性圈闭,其中岩性圈闭包括:断层沟通型和孤立型,构造—岩性圈闭包括:断层遮挡型和断层夹持型。

断层沟通型:储层砂体在上倾方向上尖灭,形成典型的上倾尖灭型圈闭,与此同时有断层沟通储层砂体和下部的烃源层系,但断层与储层顶面的构造等高线并没闭合,断层仅起沟通作用,并不起遮挡作用,如 D701 井处的圈闭就为此类型。孤立型:缺少断层沟通的砂岩透镜体,如 D703 井、D801 井,这一类圈闭目前勘探成效较差。断层遮挡型:断层在储层上倾方向形成遮挡,断层线与储层顶面构造等高线及砂体尖灭线形成闭合,D7 井和 D11 井钻探的

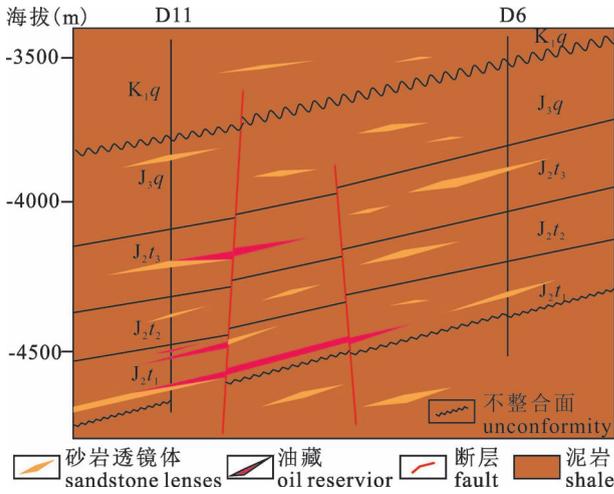


图 13 准噶尔盆地过 D11 井油藏剖面图  
 Fig. 13 Reservoir profile cross-section of D11 well

即是这种类型圈闭,在三工河组和头屯河组中油气显示较好(图 13)。

**断层夹持型:**处于走滑断层两个分支断层之间的砂体形成圈闭,D8 井和 D1 井钻探的即是这种类型的圈闭,所钻探砂体油气显示较好,D1 井头屯河组高产油流。总体来看,在四种圈闭类型之中,断层沟通型和断层夹持型圈闭勘探效果最好,可能是该区主要的勘探目标,但研究区钻井较少,随着勘探的持续、钻井的增多,需要进行深入分析。

**4.3 断层侧向封闭性影响圈闭内的油气聚集**

对于断层遮挡型圈闭,储层上倾方向断层的封闭性是需要考虑的重要因素。砂体在上倾方向上被

断层切割,那么断层对该砂体一是起到连通油源的作用,另外还起到对砂体进行错断封堵的作用,从而形成上倾断层遮挡型圈闭。目前关于断层侧向封闭性的评价方法和评价参数很多,最常用的是 Yielding 等(1997)提出了断层泥比率 SGR,SGR 能够简单而高质量地反映断面上涂抹层的非均质性(解秋红,2008;杜小亮,2011;付晓飞等,2015)。以 D8 井和 D11 井为例,利用岩性、泥质含量等数据,编制了该井储层上倾方向断层面的 SGR—Kinpe 图,SGR 值越大封闭性越好。从计算结果来看,D8 井头屯河组储层上倾方向上断层的侧向封闭性较好(图 14);而 D11 井头屯河组储层上倾方向上断层的侧向封闭性较差。D11 井头屯河组头屯河组砂体测井解释为油层和油水同层,测试结论为干层,可能与断层侧向封闭差有关(图 14)。

**5 结论**

(1)中 4 区块侏罗系以走滑断层为主,构造样式有 4 种,分别为正花状、负花状、孤立或雁列式的中等角度逆断层、近直立的缺少分支断层的走滑断层。

(2)D1 井—D1 井西区域以孤立或雁列式的中等角度逆断层为主,部分正花状构造,表现为早侏罗世拉张,中晚侏罗世压扭;D2 井北区域以负花状构造为主,构造环境为张扭;D6 井区域以直立缺少分支的走滑断层和负花状构造为主,表现为早侏罗世拉张,中晚侏罗世张扭。

(3)从时间上来说,中侏罗世,断裂平均活动速

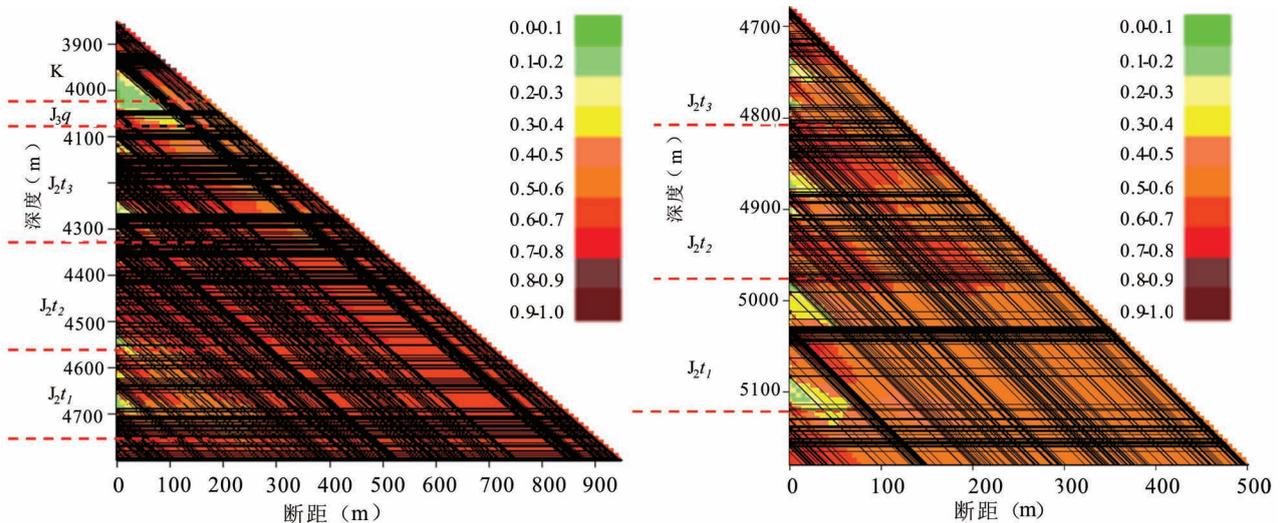


图 14 准噶尔盆地过 D8 井和 D11 井上倾方向遮挡断层 SGR 值 Kinpe 图

Fig. 14 The Kinpe figure of fault barrier SGR value of Updip direction of well D8 and well D11 (a to well D8,b to well D11)

率最强,早侏罗世次之,晚侏罗世最弱。从区域上来说,D2井北区域在早中侏罗世断裂平均活动速率最大,晚侏罗世弱于D1井—D1井西区域,D6井区域在整个侏罗纪时期断裂平均活动速率最弱。

(4)中4区块侏罗系断裂对油气输导成藏的控制作用体现在:油源断裂的发育是油气富集的首要条件;与断层有关的圈闭类型是油气富集的主要场所;断层侧向封闭性影响圈闭内的油气聚集。

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## Characteristics of Jurassic Fault and Its Control Effect on Hydrocarbon Accumulation in the Block 4 in the Middle of the Junggar Basin

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**Objectives:** Block 4 is located in the center of the Junggar basin. It contains vast quantities of recoverable oil and gas, and has huge potential for exploration and production, but in the low degree of exploration. Combining fault geometry with kinematics features, effects of Jurassic faults control hydrocarbon reservoirs are studied in this research.

**Methods:** On the basis of the study of regional tectonic stress field, dividing the type of fracture; analyzing the tectonic environment formed by fracture, and summarize the structural style of fault through intricate layer and fault interpretation, combining coherence attribute and time slice to carry out fault combination. Statistical the type of the fault (fault properties, strikes, tendencies and whether it is source fault for classification of fracture and comparison of subregional differences, by means of the balanced profile technique, calculating the fracture activity rate and the fracture kinematics characteristics. Discussing how the oil reservoir controlled by fault according to the correlation between drilling oil and gas display level and the distance from oil source fracture, compilation of reservoir profile and calculation of SGR of the upper level of drilling reservoir

**Results:** Through statistics, the number of normal faults on the plane is more than that of the reverse fault, and there is almost no relative dominance or tendency in the normal fault while the strike of the reverse fault is NW tending to be SW. Most of the faults in the work area are cut to the J<sub>1</sub>b, which can be defined as the source fault. The fault activity rate shows that the rate of D1—D1 west is 0.80~6.99 m/Ma, D2 north is 1.36~9.50 m/Ma, D6

is 0.80~6.99 m/Ma. As a whole, the fracture activity rate is the highest during the period of the Middle Jurassic ( $J_2x$ ,  $J_2t$ ); the fracture activity rate is the medium level during the Early Jurassic ( $J_1b$ ,  $J_1s$ ), the fault activity rate is the lowest during the late Jurassic ( $J_3q$ ). In the study area, four types of concealed traps are identified; the lithological traps include fault communication and fault isolation, and structural lithological traps include fault occlusion and fault clamping. The results of SGR calculation of the fault shows that the lateral sealing ability of the faults in the upper dip direction of the  $J_2x$  of D8 well is better, and the lateral sealing property of the upper dip direction of the  $J_2t$  reservoir in D11 well is poor.

**Conclusions:** The Jurassic faults in the study area are mainly strike-slip faults, with four patterns: positive flower structure, negative flower structure, up-right strike slip fault with a lack of branch faults, and Isolated or echelon medium angle reverse fault. Dong 1— Dong 1 western area is characterized by medium angle isolated or echelon fracture abnormal faults. Some of the faults have positive flower structure which represent extension in the early stage of Jurassic and compresso-shear in the and late stage of Jurassic. Dong 2 northern area has the characteristics of negative flower structure with the mechanism of transtension. Dong 6 area has the feature of negative flower and strike-slip faults with lack of brunch. Those features show extension happened in the early stage of Jurassic and transtension happened in the middle and late stage of Jurassic. Temporality, the highest average fault activity rate happened in the middle stage of Jurassic. The early stage of Jurassic average fault activity rate is lower than the rate in the middle stage of Jurassic and better than the rate in the late stage of Jurassic is the lowest. Spatially, Dong 2 northern area has the highest average fault activity rate in the early to middle stage of Jurassic, the rate is lower than Dong 1— Dong 1 western area in the late stage of Jurassic. Dong 6 area has the lowest average fault activity rate during Jurassic. The effects of how faults control hydrocarbon migration show in the following aspects: the faults in reservoir rocks is the primary control of hydrocarbon enrichment; faults traps is the main storage space for hydrocarbon; lateral sealing of trap influence hydrocarbon accumulation.

**Keywords:** block 4 in the center of the Junggar Basin, Jurassic, stike-slip fault, average fault activity rate (AFAR), hydrocarbon accumulation

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