

## 鄂尔多斯盆地北部二叠系下石盒子组 洪水泥石流与牵引流沉积特征

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**摘要:**以鄂尔多斯盆地北部苏里格气田的苏76、苏77区块下石盒子组盒8段为研究对象,运用岩相分析方法探讨二叠系下石盒子组盒8下段沉积演化过程中的岩相类型、叠置关系及其反映的沉积相特征。通过对研究区内38口探井取芯段岩芯的详细观察和描述,首次识别出了由洪水泥石流沉积所形成的岩相和由牵引流沉积所形成的岩相。牵引流沉积所形成的岩相主要包括颗粒支撑的正砾岩相、牵引流成因含砾粗砂岩相、牵引流成因砂岩相和牵引流成因粉砂质泥岩相;洪水泥石流沉积所形成的岩相包括杂基支撑的副砾岩、洪泛成因含砾粗砂岩相和洪泛成因粉砂质泥岩相。这二种沉积作用所形成的岩相在垂向上叠置构成不同的岩相组合类型。这些组合类型反映了苏76、苏77区块盒8下段在洪水泥石流沉积期发育湿冲积扇沉积,在牵引流沉积期发育辫状河沉积。其中,辫状河道中发育砾石质心滩、砾砂质心滩、砂质心滩,为形成有利储集砂体提供了条件。

**关键词:**岩相;洪水泥石流;牵引流;下石盒子组;二叠系;苏里格气田;鄂尔多斯盆地

**中图分类号:**P618.13;TE121.3

**文献标志码:**A

### Sedimentary Characteristics of Flood Debris Flow and Traction Current in the Lower Shihezi Formation of Permian in the Northern of Ordos Basin

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**Abstract:** He-8 section of the Lower Shihezi Formation of Permian in Su76 and Su77 blocks of Sulige gas field, the northern Ordos Basin was taken as an example; lithofacies type and superimposed relation during the sedimentary evolution of the lower section of He-8 in the Lower Shihezi Formation of Permian were discussed by the means of petrographic analysis, and the characteristics of sedimentary facies were analyzed. According to the detail observation and description of rock cores from 38 exploration wells in the study area, two types of sedimentary lithofacies formed by flooding debris flow and traction current were identified. The lithofacies formed by traction current includes orthoconglomerate lithofacies supported by grain, coarse sandstone lithofacies with gravel, sandstone lithofacies and mudstone lithofacies with silty because of traction current; the lithofacies formed by flooding debris flow includes paraconglomerate lithofacies supported by matrix, coarse sandstone lithofacies with gravel and mudstone lithofacies with silty because of flooding. Different combination types of lithofacies are

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vertically superimposed because of the lithofacies formed by the two types of sedimentation. The combination types reflect that wet alluvial fan develops during the deposition period of flooding debris flow, and braided river develops during the deposition period of traction current in the lower section of He-8, Su76 and Su77 blocks. Gravelly diara, gravelly sandy diara and sandy diara develop in braided channel, and it is favorable to forming reservoir sand bodies.

**Key words:** lithofacies; flood debris flow; traction current; Lower Shihezi Formation; Permian; Sulige gas field; Ordos Basin

## 0 引言

针对鄂尔多斯盆地北部苏里格气田下石盒子组盒 8 下段,前人进行了大量研究,取得了不同成果<sup>[1-10]</sup>。胡光明等认为该气田下石盒子组盒 8 下段为河流相沉积<sup>[11]</sup>;白全明等认为其为辫状河沉积<sup>[12-14]</sup>;付锁堂等认为其为三角洲沉积<sup>[15-17]</sup>。笔者在前人研究成果的基础上,通过对苏里格气田苏 76、苏 77 区块的 38 口探井取芯段的岩芯详细观察和描述,运用岩相分析方法对二叠系下石盒子组盒 8 下段沉积演化过程中的岩相类型、叠置关系及其反映的沉积相特征进行深入分析,为该区块盒 8 下段进一步勘探与开发提供基础资料和科学依据。

## 1 研究区地质概况

位于鄂尔多斯盆地北部苏里格气田的苏 76、苏 77 区块(图 1)北起加不沙,南至乌审召,西至苏 76-1-1 井,东到召 64 井,面积约 1 925 km<sup>2</sup><sup>[18-25]</sup>。该区二叠系下石盒子组自下而上划分 4 段(盒 8 段、盒 7 段、盒 6 段和盒 5 段),地层厚度 120~160 m,主要为一套浅灰色含砾粗砂岩、灰白色中粒砂岩夹砾岩、泥岩。盒 8 段根据岩性、旋回及测井响应又分为 4 个小段,其中盒 8 下段为主要产气层位之一。

## 2 洪水泥石流沉积的岩相类型及其特征

岩相是指在一定条件下形成的岩石类型及其沉积构造的综合,相当于沉积能量单元<sup>[26-30]</sup>。古洪水

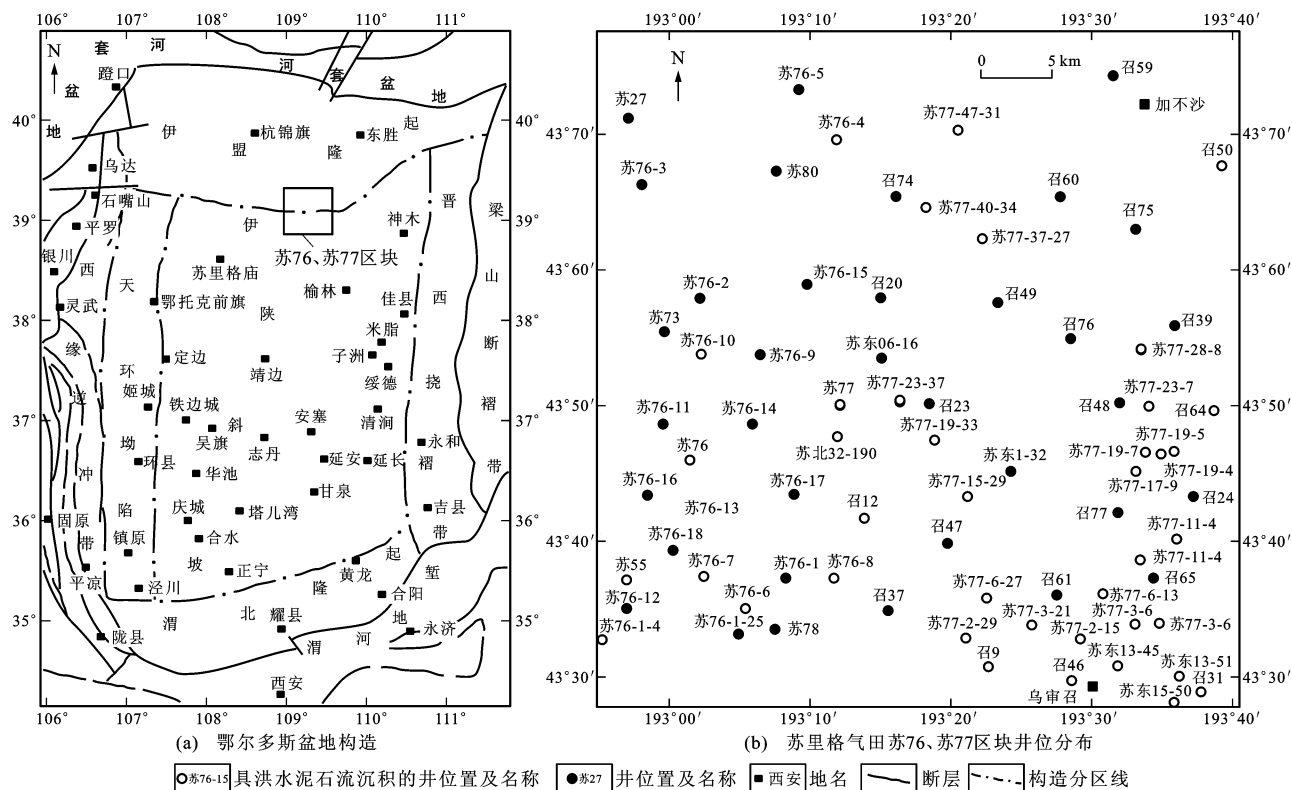


图 1 研究区位置及井位分布  
Fig. 1 Location of Study Area and Distribution of Wells

事件最终所形成的特殊岩相类型,对于恢复当时古气候条件、探讨古地理面貌、分析储层发育的影响因素具有重要的理论意义和实际价值。研究区下石盒子组盒8下段沉积时广泛发育与洪水事件有关的洪水期洪泛泥石流沉积记录。

### 2.1 杂基支撑的副砾岩相

杂基支撑的副砾岩相为洪水期泥、砂、砾混杂搬运,洪水减退流速减缓时泥、砂、砾混杂沉积所形成的,包括两种类型:①泥、砂充填于砾石间形成基质支撑的副砾岩相(图2);②全部由泥质支撑的副砾岩相(图3)。



岩芯取自召75井盒8下段

图2 泥、砂充填基质支撑的副砾岩相

Fig. 2 Paraconglomerate Lithofacies Filled with Mud and Sand and Supported by Matrix



岩芯取自召50井盒8下段

图3 泥质充填支撑的副砾岩相

Fig. 3 Paraconglomerate Lithofacies Filled and Supported by Mud

副砾岩相最终是泥、砂充填基质支撑还是泥质充填支撑,与洪水期物源供给、洪水的黏性有关。比如,召50井盒8下段为典型的泥质充填支撑的副砾岩相(图3)。

### 2.2 洪泛成因含砾粗砂岩相

洪泛成因含砾粗砂岩相以灰白色含砾粗粒砂岩为主,砾石含量(体积分数,下同)大于15%,其中常有漂砾。根据砾石含量、大小以及砂质含量变化,洪泛成因含砾粗砂岩相可分为正、反韵律及旋回,形成向上变粗或变细的递变层理(图4)。

### 2.3 洪泛成因粉砂质泥岩相

洪泛成因粉砂质泥岩相主要由紫红色、杂色粉砂质泥岩组成,发育水平层理,系溢岸泛滥平原(洪泛平原)沉积。比如,召76井盒8下段、召37井盒



(a) 岩芯取自苏77井盒8下段,含砾粗砂岩相中递变层理,含砾粗砂岩向上变粗,砾石向上变大



(b) 岩芯取自苏77井盒8下段,含砾粗砂岩相中正递变,砾石向上变小

图4 洪泛成因含砾粗砂岩相

Fig. 4 Coarse Sandstone Lithofacies with Gravel Because of Flooding

8下段均为典型的洪泛成因粉砂质泥岩相。

## 3 牵引流沉积的岩相类型及其特征

研究区石盒子组盒8下段沉积时除广泛发育洪水泥石流沉积以外,主体仍为正常沉积作用下的牵引流沉积。

### 3.1 颗粒支撑的正砾岩相

颗粒支撑的正砾岩相特征表现为岩性以中、细砾岩为主。该岩相常有两种情形:①砾石磨圆度好,分选度差,如召75井盒8下段、召59井盒8下段;②砾石磨圆度差、分选度差,如召39井盒8下段、召76井盒8下段。沉积构造主要有块状层理、递变层理(正或反)、平行层理、板状层理、槽状层理(图5)。

### 3.2 牵引流成因含砾粗砂岩相

牵引流成因含砾粗砂岩相主要由灰白色含砾粗粒砂岩组成,砾石含量大于15%,砾石呈叠瓦状构造。此类岩相常出现在砾石砂质心滩的辫状河中。根据砾石含量、大小以及砂质含量的变化,该岩相可分正、反韵律及旋回,形成递变层理(图6),除此之外,还有块状层理、槽状交错层理、板状交错层理、平行层理含砾粗砂岩相。比如,在召47井盒8下段发育具有槽状交错层理的含砾粗砂岩相。

### 3.3 牵引流成因砂岩相

研究区盒8下段所发育的牵引流成因砂岩相以粗粒砂岩相、中粗粒砂岩相为主,沉积构造主要为块





图5 颗粒支撑的正砾岩相

Fig. 5 Orthoconglomerate Lithofacies Supported by Grain



图6 牵引流成因含砾粗砂岩相

Fig. 6 Coarse Sandstone Lithofacies with Gravel  
Because of Traction Current

状层理、板状交错层理、槽状交错层理、平行层理。比如,召24井盒8下段砂岩中发育槽状和板状交错层理等(图7)。



图7 牵引流成因砂岩相

Fig. 7 Sandstone Lithofacies Because of Traction Current

### 3.4 牵引流成因粉砂质泥岩相

牵引流成因粉砂质泥岩相主要由黑色粉砂质泥岩组成,为辫状河道发育期间河流上部旋回产物。其发育厚度和规模非常小,个别钻井中可见到。

## 4 岩相组合类型及沉积相特征

### 4.1 副砾岩相与正砾岩相组合类型

副砾岩相与正砾岩相组合代表了洪水事件发生

期间由洪水泥石流沉积作用所形成的砂泥混杂、杂基支撑的副砾岩与正常牵引流沉积作用所形成的颗粒支撑的砂砾岩垂向叠置。其中,杂基支撑的副砾岩为冲积扇上的泥石流沉积,而颗粒支撑的砂砾岩为辫状分支河道心滩沉积。通过对研究区钻遇盒8下段取芯井的统计,53%钻井中均发育有颗粒支撑的正砾岩岩相与杂基支撑的副砾岩岩相叠置的组合类型(图8)<sup>[16-17]</sup>。

苏77井盒8下段包括了3个副砾岩相与正砾岩相组合旋回,反映了盒8下段经历了3次洪水泥石流沉积与牵引流沉积(图9、10)。每一旋回都经历了洪泛涨水期块状基质支撑的副砾岩相到洪水退却后的滩辫状河含砾粗砂岩相以及板状交错层理与平行层理交替的粗砂岩相的演化。另外,召39井盒8下段也经历了类似的沉积演化(图11)。

### 4.2 不同砂岩相组合类型

苏77、苏76区块盒8下段砂岩岩相类型多样,根据垂向叠置关系可划分为两种组合类型:①钟型及叠置钟型组成向上变细序列;②漏斗或叠置漏斗型组成的向上变粗序列。比如,召48井盒8下段第一次取芯深度为2 902~2 917 m,岩性为中粗粒砂岩相(图12),岩相组合序列从下向上为块状杂基支撑的副砾岩相、具低角度斜层理的砂岩相、具低角度斜层理的含砾粗砂岩相、具平行层理的含砾粗砂岩相、具槽状层理的含砾粗砂岩相、具低角度斜层理的砂岩相、具平行层理的砂岩相、具低角度斜层理的砂岩相、具槽状层理的砂岩相、具低角度斜层理的砂岩以及具槽状层理的砂岩相。这种岩相组合特征表明:开始的洪泛涨水沉积迅速变为洪水退却沉积,再到以常年牵引水流沉积为主,水流状态呈高流态与低流态交替。苏77井、召46井盒8下段也具有这种特征。

### 4.3 盒8下段沉积相特征

上述岩相类型及组合反映了研究区下石盒子组盒8下段沉积期洪水泥石流沉积与牵引流沉积交替出现。其中,洪水泥石流沉积厚度相对薄。那么,出现上述交替沉积序列的沉积环境只有冲积扇。研究区紧靠北部阴山古陆,伴随着古陆的抬升,物源供给增强,季节性水流异常活跃,盒8下段便形成冲洪积扇相沉积。在季节性水流间隙期,盒8下段为正常的辫状河道沉积,在河道内发育砂质心滩、砾砂质心滩、砂质心滩(图13)。

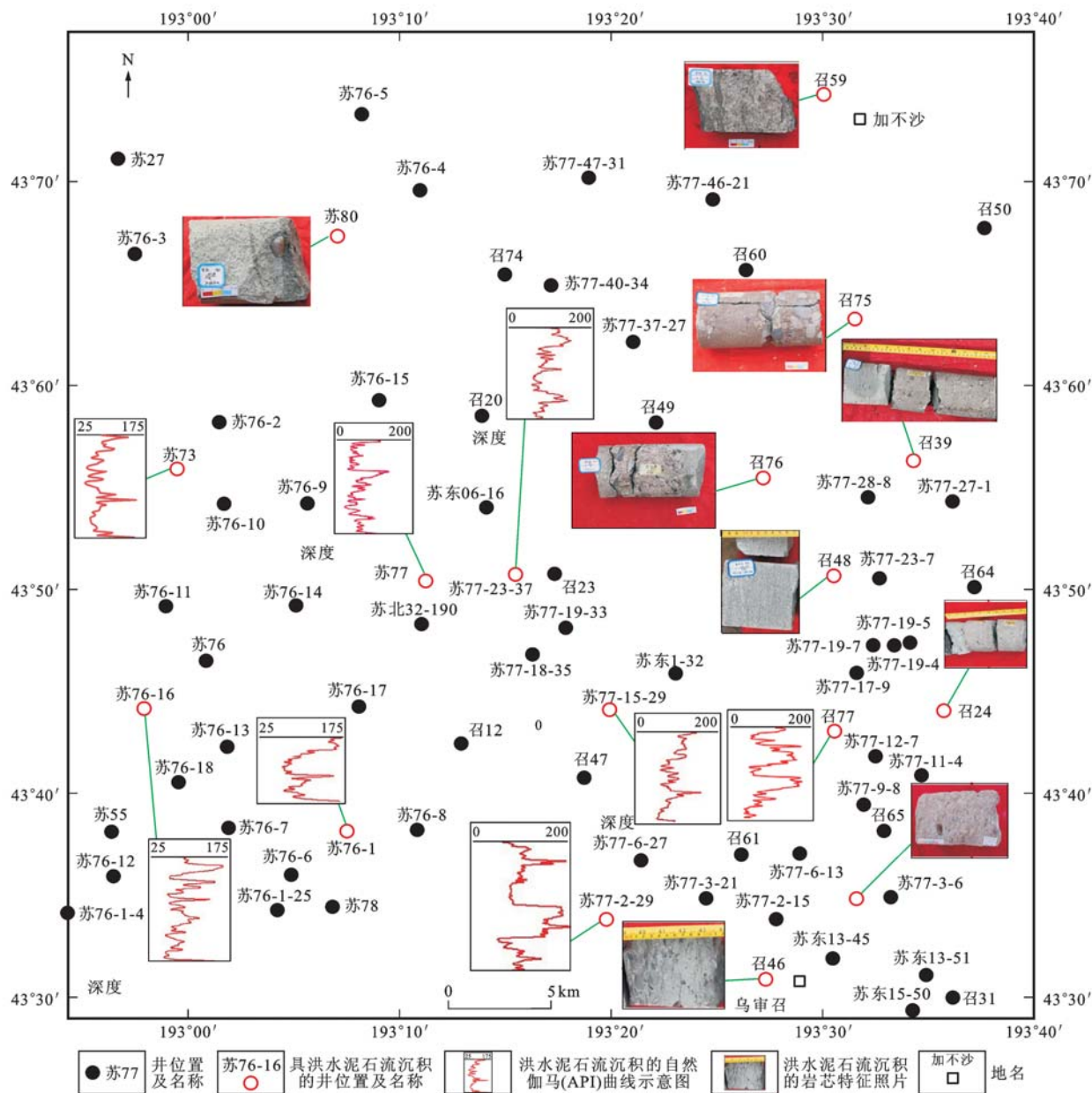


图8 盒8下段牵引流与洪水泥石流沉积组合在钻井中的分布

Fig. 8 Distribution of the Sedimentary Combination Formed by Traction Current and Flooding Debris Flow in the Lower Section of He-8

## 5 结 语

(1)鄂尔多斯盆地北部二叠系下石盒子组盒8下段岩相类型多样,既有洪水泥石流沉积所形成的岩相,也有牵引流沉积所形成的岩相。其中,洪水泥石流沉积的岩相包括杂基支撑的副砾岩相、洪泛成因含砾粗砂岩相和洪泛成因粉砂质泥岩相。牵引流沉积的岩相包括颗粒支撑的正砾岩相、牵引流成因含砾粗砂岩相、牵引流成因砂岩相和牵引流成因粉砂质泥岩相。

(2)洪水泥石流沉积和牵引流沉积作用所形成的岩相在垂向上构成了不同的岩相组合类型,主要

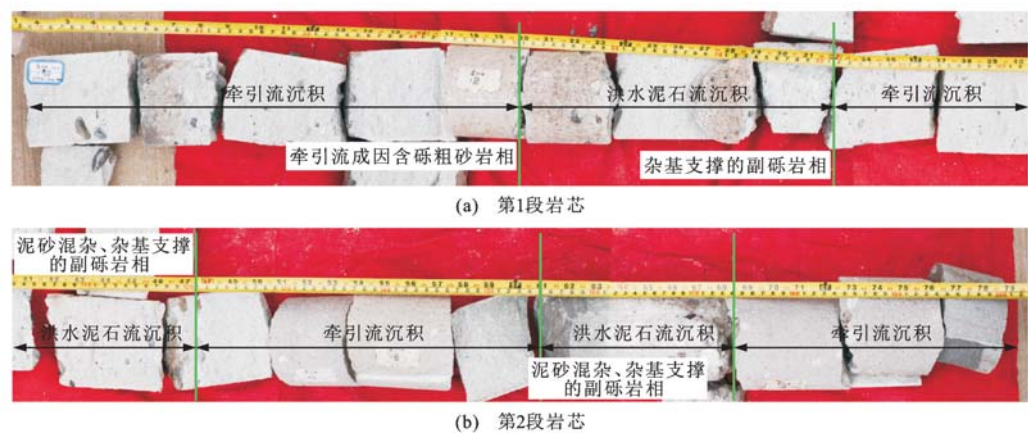
包括副砾岩相与正砾岩相组合类型以及不同砂岩相组合类型。其中,砂岩相组合类型进一步细分为向上变细和向上变粗的砂岩相组合类型。

(3)上述岩相组合说明研究区盒8下段在洪水泥石流沉积期发育湿冲积扇沉积,在牵引流沉积期发育辫状河沉积。其中,辫状河河道中发育砾石质心滩、砾砂质心滩、砂质心滩,为形成有利储集砂体提供了条件。

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岩芯取自苏 77 井盒 8 下段,深度为 3 138.2~3 140 m

图 9 不同成因岩相组合类型

Fig. 9 Combination Types of Lithofacies with Different Genesis

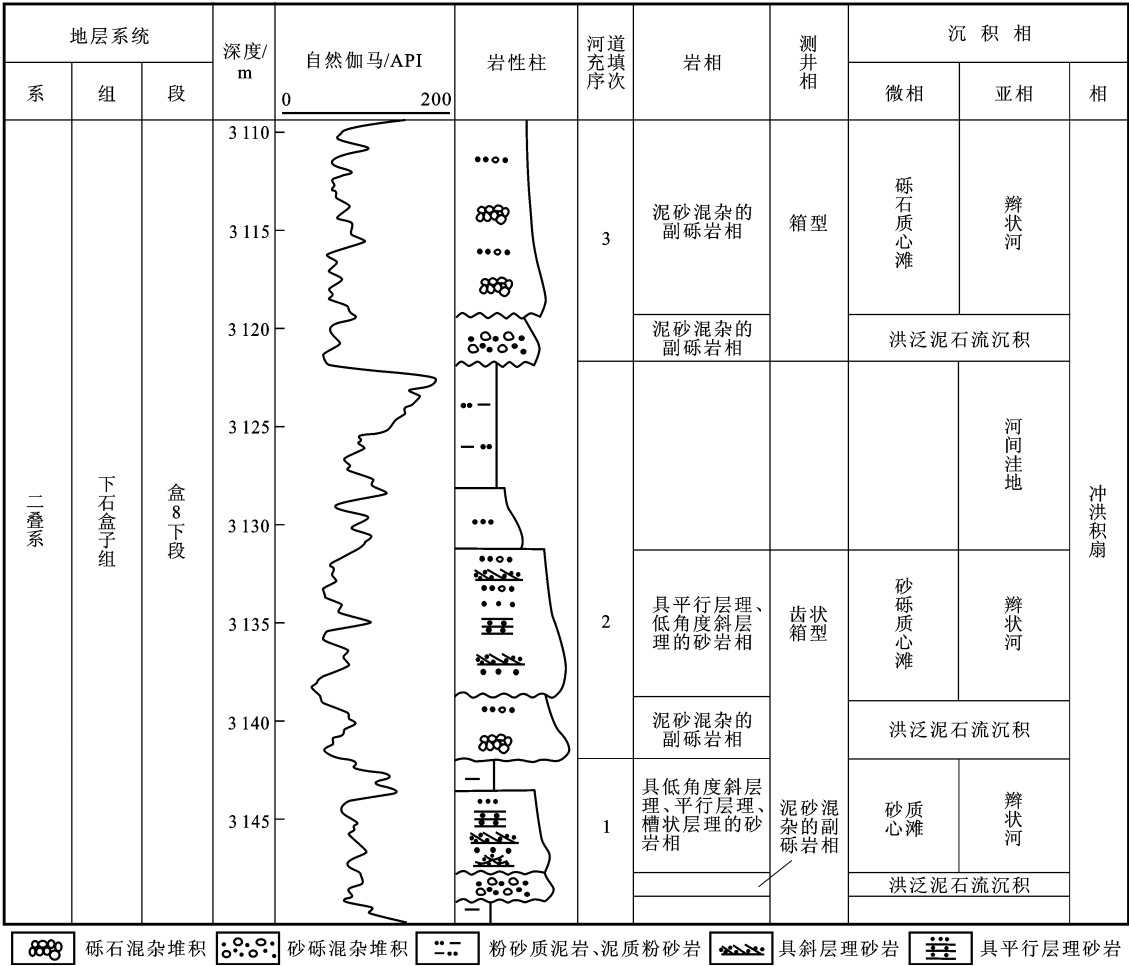


图 10 苏 77 井盒 8 下段洪水泥石流与牵引流沉积岩相叠置的特征

Fig. 10 Superimposed Characteristics of Sedimentary Lithofacies Formed by Flooding Debris Flow and Traction Current in the Lower Section of He-8 from Well Su77

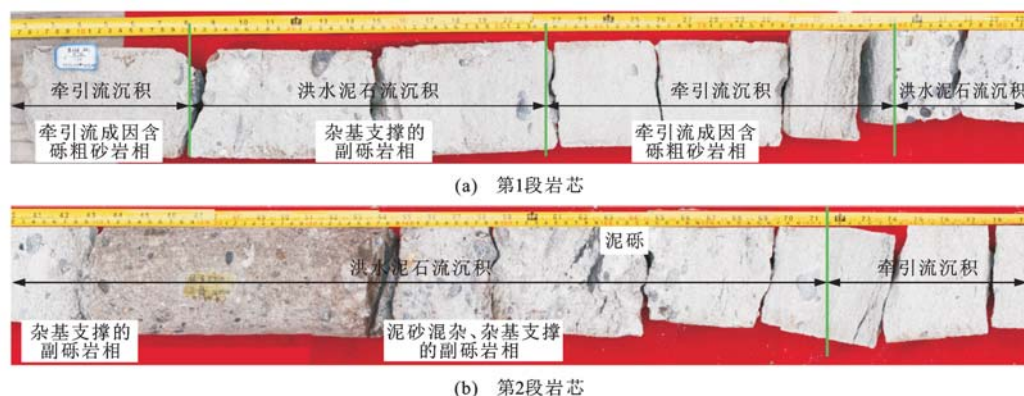
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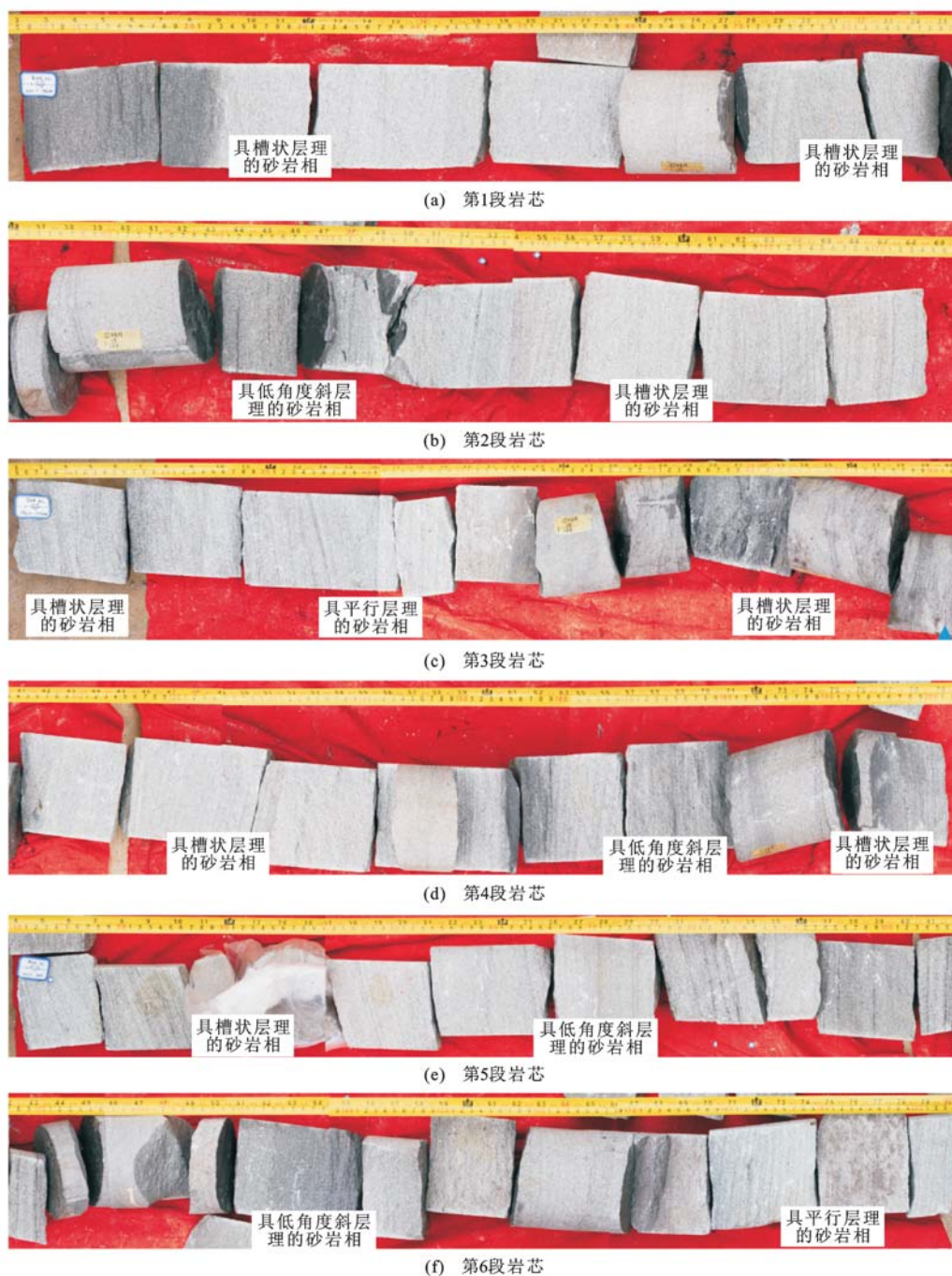


岩芯取自召39井盒8下段,深度为2 874.06~2 876 m

图11 洪水泥石流与牵引流沉积岩相组合特征

Fig. 11 Combined Characteristics of Sedimentary Lithofacies Formed by Flooding Debris Flow and Traction Current

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岩芯取自召 48 井盒 8 下段, 深度为 2 902.8~2 908 m

图 12 砂质心滩岩相组合特征

Fig. 12 Combined Characteristics of Lithofacies with Sandy Diara

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