PS Research on Architecture Pattern of Deepwater Turbidity Channel in X Oilfield of Neogene, West Africa*

Lin Yu[1], Shenghe Wu[1], Yao Lu[1], and Qionghua Wan[1]

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[1]State Key Laboratory of Petroleum Resource and Prospecting, Beijing, China (lin66yu@yahoo.com)

Abstract

Turbidity channels are an important reservoir style of submarine fans. Although many researchers have carried out studies on the architectures of turbidity channels, the morphology, scale and superimposed style of low-graded architecture units have not been deeply understood. Taking X oilfield of Neogene in West Africa as an example, architecture patterns of turbidity channels from three hierarchies (channel complex set, channel complex, elementary channel) are studied and the 3-D reservoir architecture models of turbidity channels are built. The results depend on a variety of high-quality data of the study area. There are 34 wells altogether (the minimum well space is 200m) and 500m systematic core data. It also has high-resolution 3-D seismic data (dominant frequency is 65HZ). The methods such as core observation and description, well logging analysis, seismic spectral decomposition and seismic strata slicing are utilized in the analysis procedure. Finally, four conclusions are obtained from this project. (1) Elementary channels are 300-600m wide and 10-30m deep. When the bend curvature reaches 1.6, the channel is defined as high-sinuosity channel. The cut-off happens for the channel interval when its bend curvature reaches 6. (2) Elementary channels, based on internal filling characteristics, can be grouped as slump-filling channel, high-density sandy channel, low-density sandy channel (internal beddings are evident) and mud abandoned channel. In view of the intensity and direction of erosion process, elementary channels can be classified as longitudinal erosion-dominant channel, lateral erosion-dominant channel and weakly erosional channel. (3) The channel complex manifests various superimposed styles, including (a) disordered style, (b) lateral amalgamated style, (c) inclined en echelon style, (d) vertical swinging style and (e) solitary style. Vertically, the channel complexes have a rule of evolution from (a) to (e) upwards. (4) Along the source direction, the confined degree of channel complex sets varies in a character of decreased-increased-decreased. The bend curvature of channel complex set has a logarithmic relation with aspect ratio and a power relation with slope gradient.

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1. State Key Laboratory of Petroleum Resource and Prospecting, Beijing, China.

1 Introduction

Turbidity channel of submarine fan is an important reservoir type. Many studies on the architecture of turbidity channel have been carried out, but the understandings of the morphology, scale and superimposed style of low-graded architecture units have not been so deeply. This study, taking one oilfield of Neogene in West Africa as an example, carries out the research about architecture patterns of turbidity channel from three hierarchies: channel system, channel complex, single channel. The study area has 34 wells altogether, with minimum well spacing being 200m and systematic coring 500m approximately. Also, the dominant frequency of 3D seismic data is 65HZ. Those data are comprehensively utilized using methods such as core observation and description, well logging discriminant analysis, seismic spectral decomposition and seismic strata slicing. This study brings deep understandings to the turbidity channel geological theory and it also reduces the risk on exploration and development about this type of reservoir.

2 Channel system

Using high-quality shallow seismic data, the correlation between the sinuosity of confined channel system and the slope gradient is analyzed quantitatively. In order to eliminate the impact of deuteric tectonic movement to the utmost extent, six shallow channel systems are selected as samples which present in the seafloor of the study area. The result shows that sinuosity of turbidity channel system is controlled by gradient of slope and has a negative correlation. As the slope gradient increases, the sinuosity of channel system decreases. Channel system is nearly straight when the slope gradient is up to 4 degree (Fig.1).

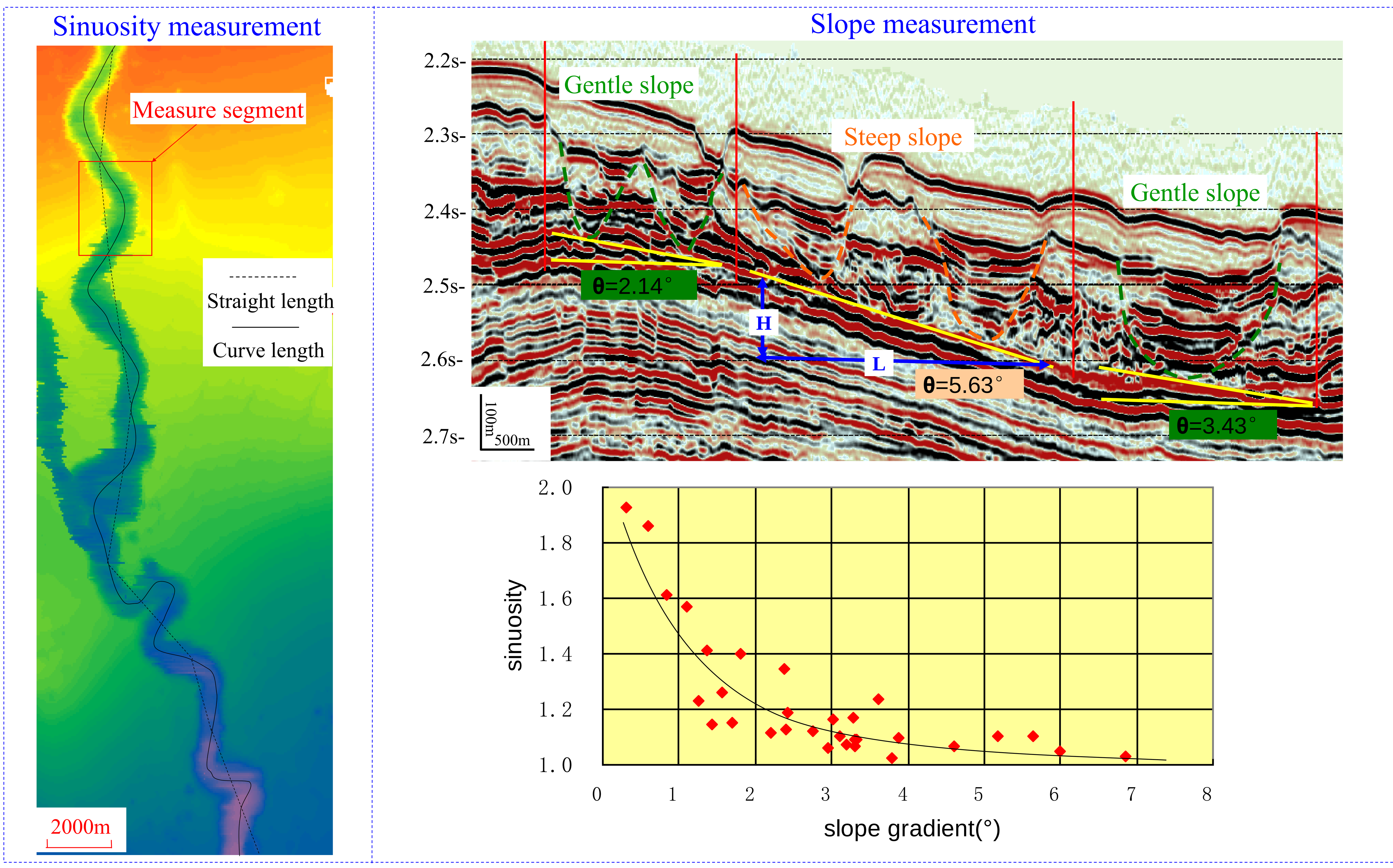


Fig.1 Measurement method and result from sinuosity of channel system and gradient of slope

3 Channel complex

3.1 Composite patterns and distribution rule

(1) There are various composite patterns of turbidity channels through the anatomy of architectural elements of the deep turbidity channels in the local dense well area pattern. According to direction and mass of migration among single channels, the composite patterns can be divided into 4 types (lateral composite, en-echelon composite, swinging composite and vertical composite) and 13 subtypes (Fig.2～Fig.3).

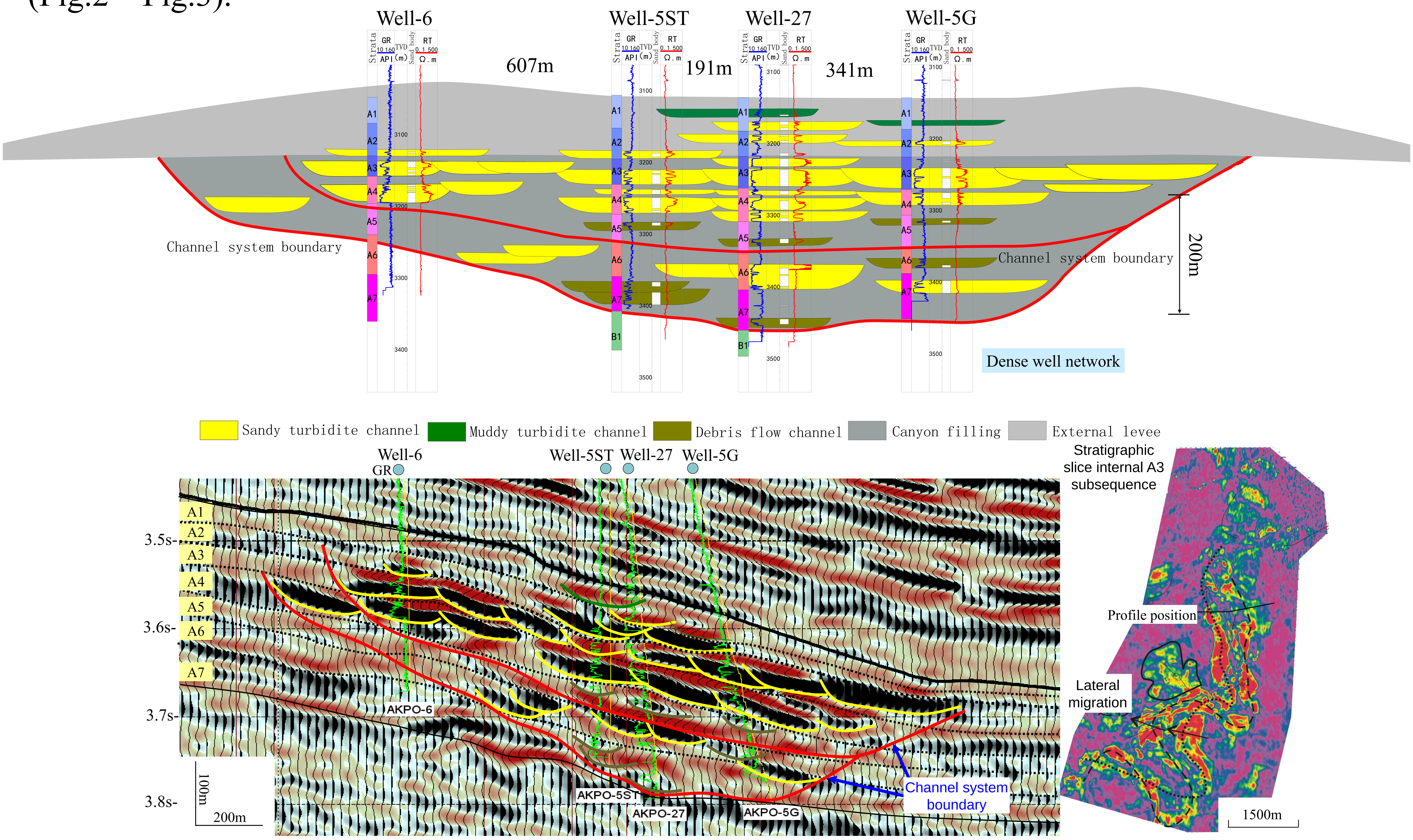


Fig.2 Anatomy of composite patterns of single channel in dense well network area of research area

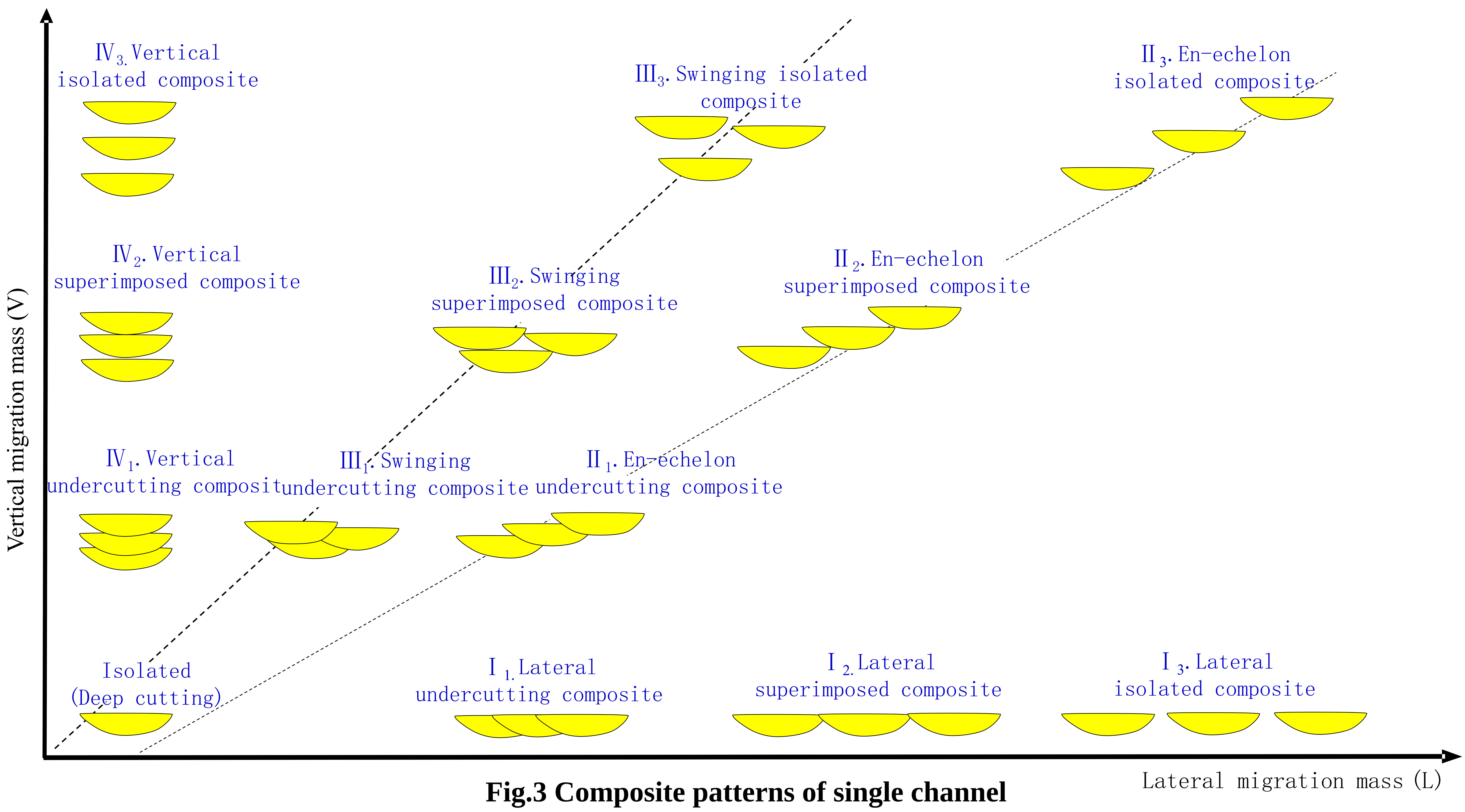


Fig.3 Composite patterns of single channel

(2) The composite patterns at different evolution stages and different positions of a confined channel system: In general, at the initial evolution stage, the composite patterns are undercutting composite and isolated; At the middle evolution stage, composite pattern is lateral composite; At the middle-late evolution stage, composite patterns are en-echelon and swing composite; And at the late evolution stage, composite pattern is vertical composite; For the meandering channel complex, which develops in the middle-late evolution stage of confined channel system, swing composite pattern is mainly located at the straight segment, and en-echelon composite pattern is mainly located at the meandering segment (Fig.4).

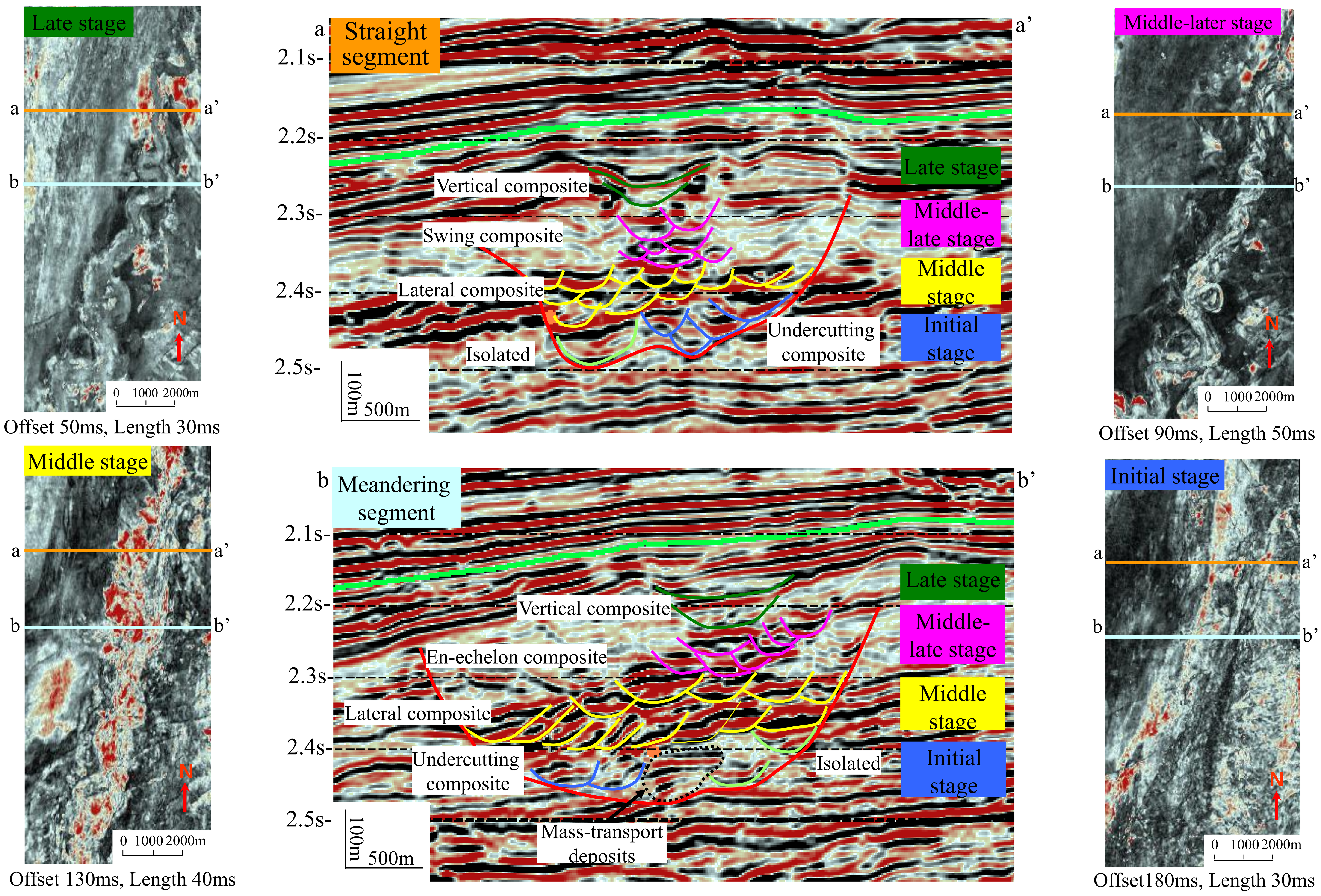
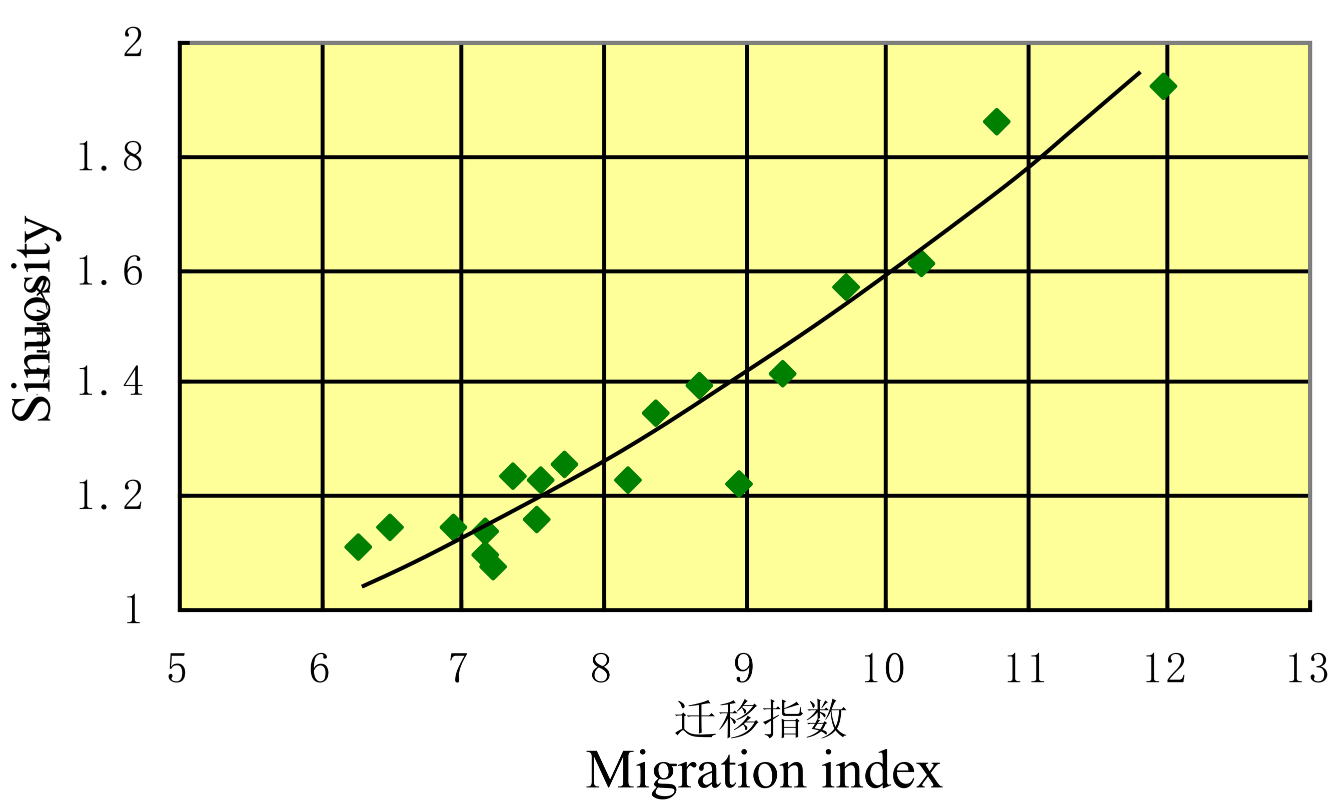


Fig.4 Distribution rule of composite pattern of single channel

3.2 Relation between sinuosity and migration index of channel complex

For the meandering channel complexes which have the same migration times, the sinuosity and migrating index (the value of this parameter can be defined as the ratio of lateral and vertical migration amount) are closely related. To some extent, there is a positive correlation between them(Fig.5).



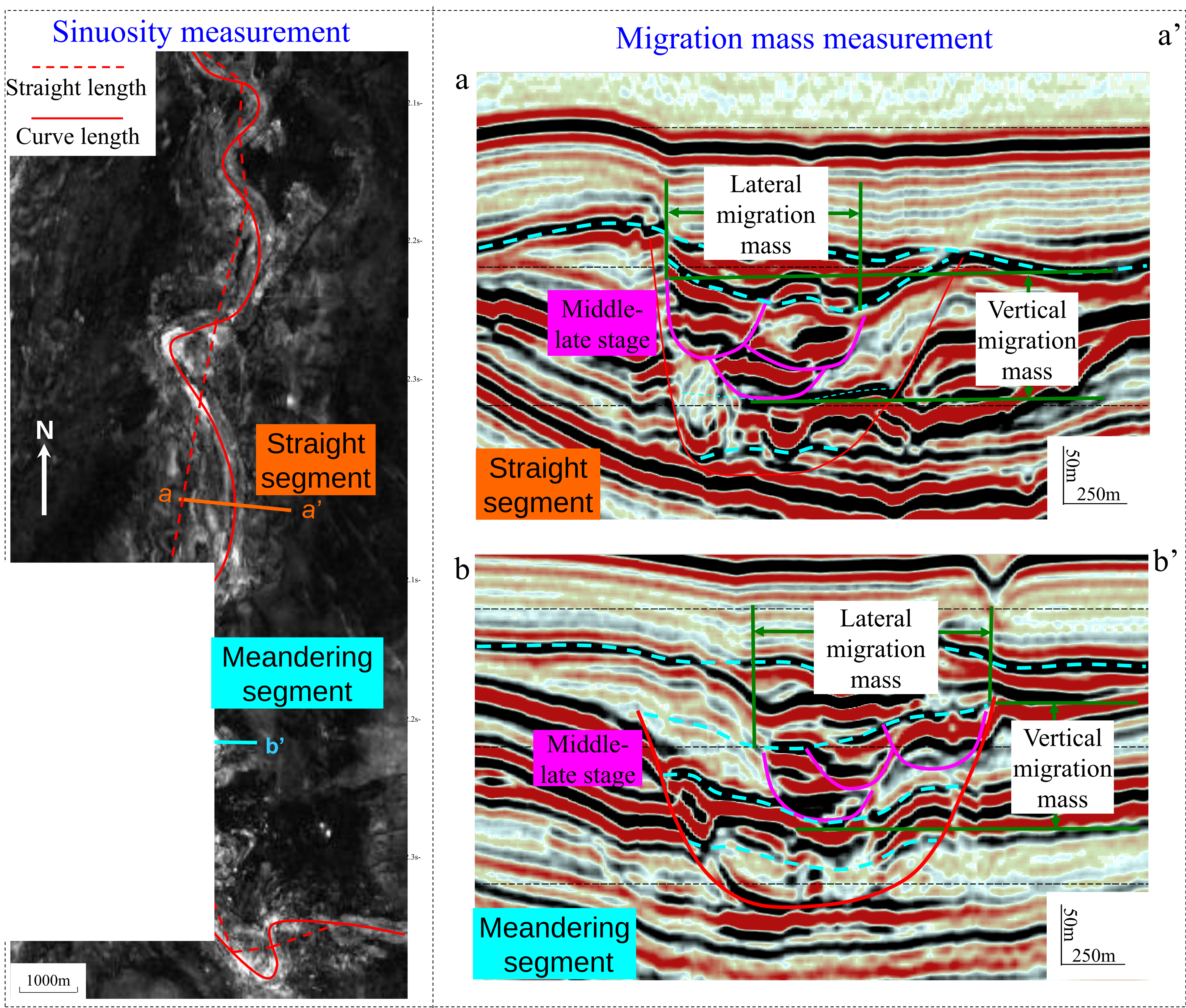


Fig.5 Measurement method of sinuosity and migration index of meandering channel complex

3.3 Migration character of single channel in a channel complex

(1) Within a channel complex, single channel migration is integral, and two migration patterns are identified including lateral migration and downdip migration (Fig.6a).

(2) The shingled reflection feature of channel complex in the seismic profile are the comprehensive seismic responses which are formed by the integral migration of multiple channels along some direction (Fig.6b).

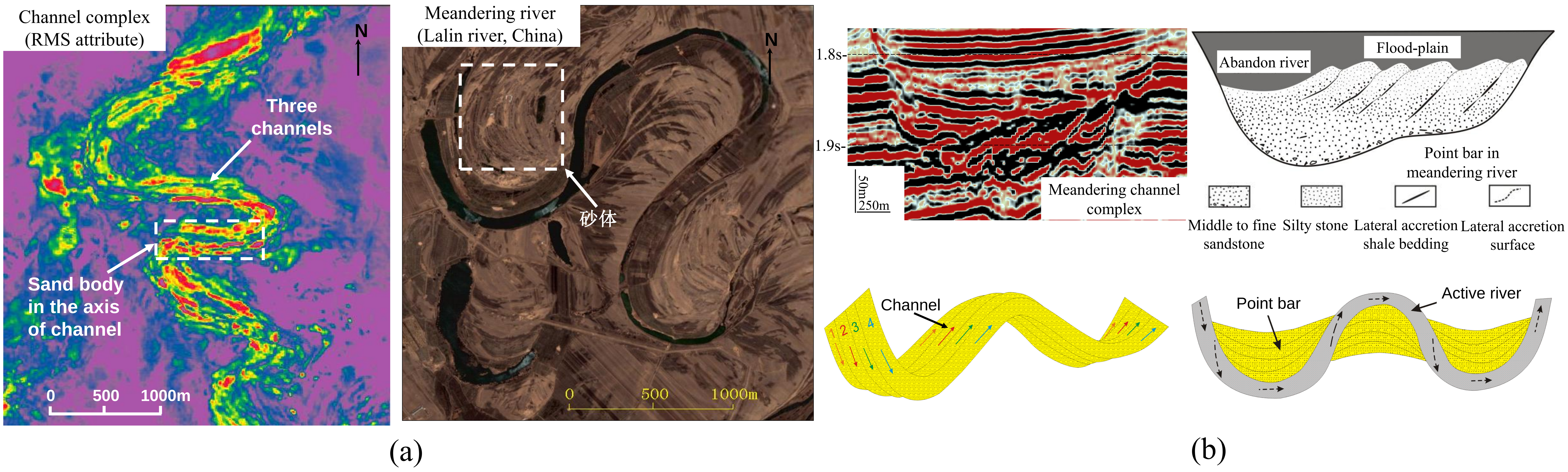


Fig.6 Comparison of plane and profile character between single channel and point bar in meandering river

(3) The migration of channels of different periods in a channel complex are inherited. The sinuosity of single channel is relatively low in early stage (mostly between 1.1 and 2.2) and some segments are straight; The sinuosity of single channel is high in middle-late stage (mostly between 1.5 and 3.5) because of sustained migration. And cutoff may happen locally when the sinuosity is up to 5 (Fig.7).

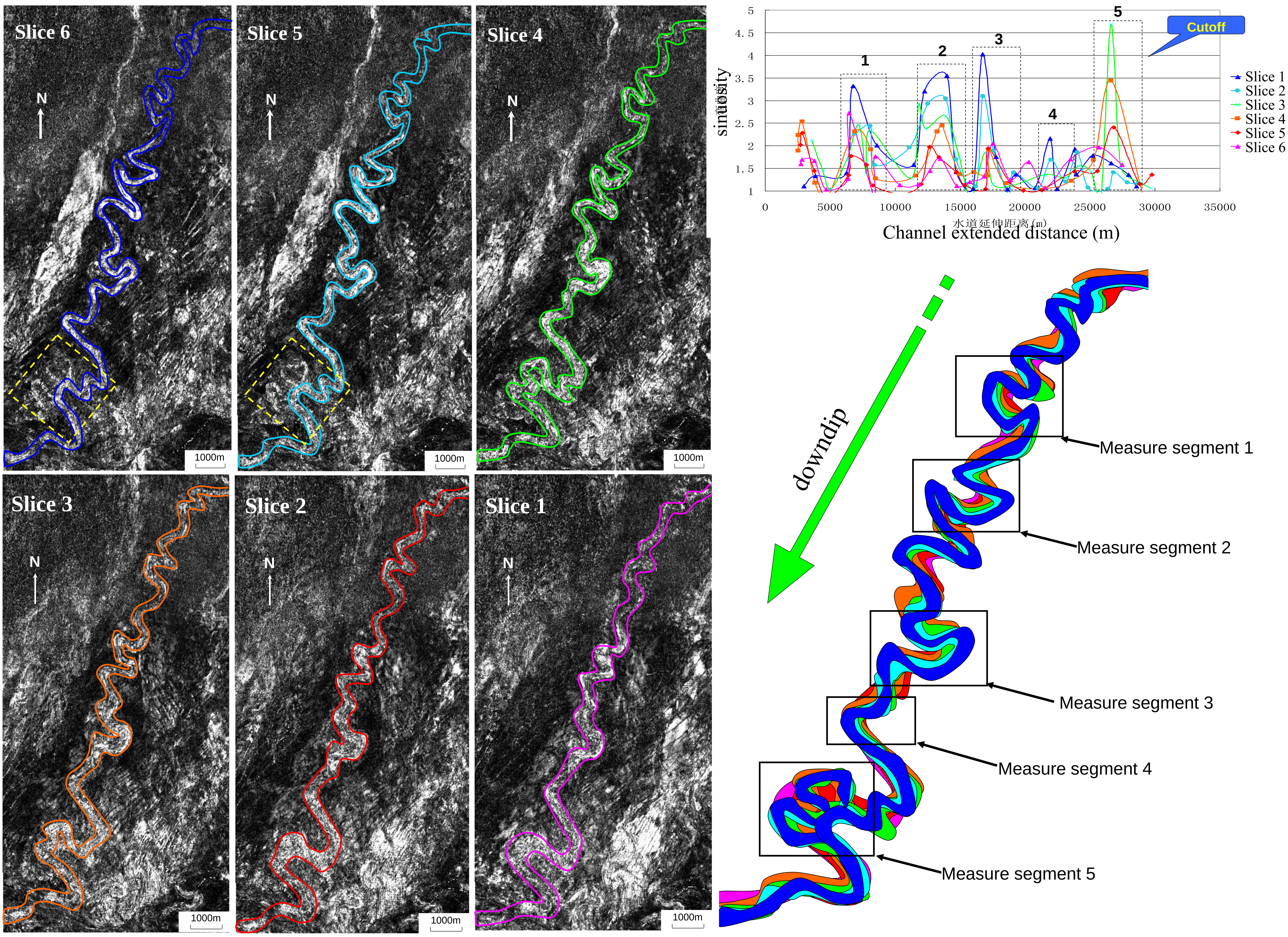


Fig.7 Migration character of single channel inner a channel complex

4 Single Channel

4.1 Types and distribution rule

According to litho-facies differences, single channel can be divided into 4 types (type Ⅰ to type Ⅳ). Type Ⅰ is mainly filled with muddy deposits, type Ⅱ is mainly filled with sandy low-density turbidity deposits, type Ⅲ is mainly filled with sandy high-density turbidity deposits, and type Ⅳ is mainly filled with both sandy high-density turbidity deposits and debris flow deposits (Fig.8). A trend of type Ⅳ → type Ⅲ→ type Ⅱ→ type Ⅰ is found from bottom upward within a channel system.

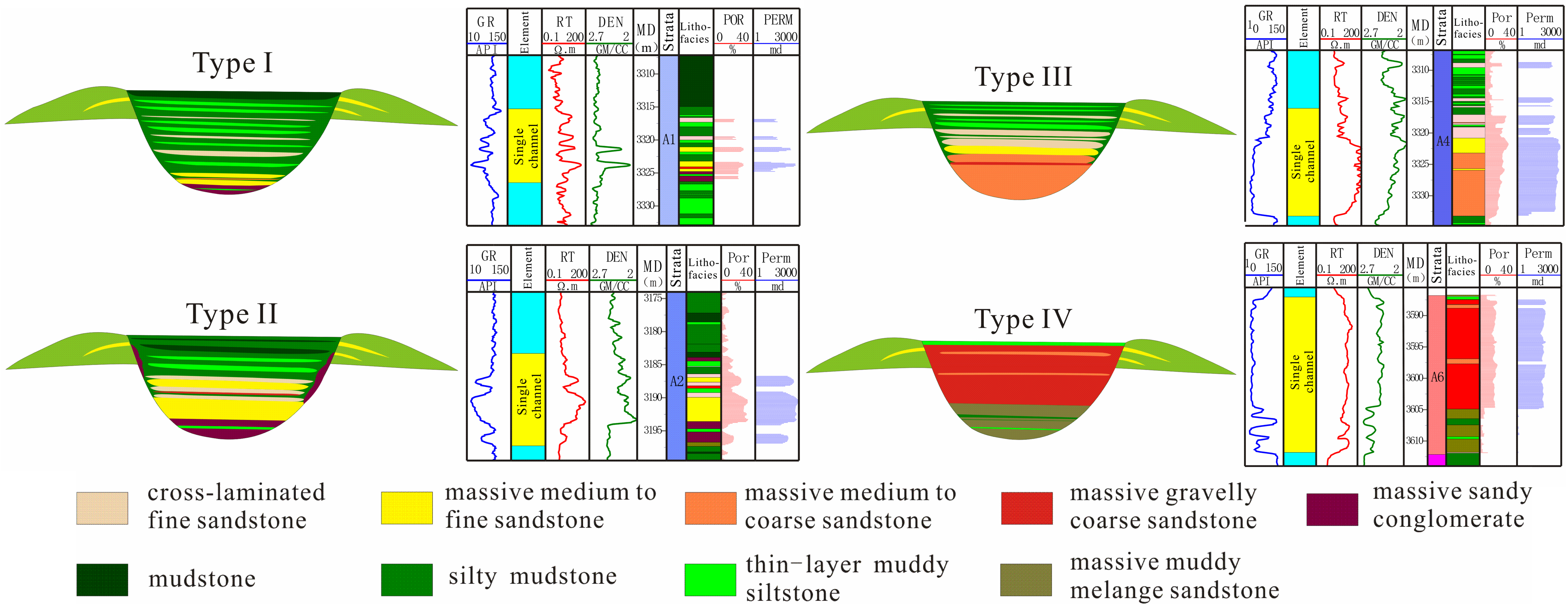


Fig.8 Lithological and electrical characteristics of different types of single channel

4.2 Scale and quantitative relation

The width of single channel has a positive function with its depth. The width of single channel is about 150m～500m, and depth is about 10m～30m. Thus, the width-depth ratio of single channel is about 12 to 20, and it is larger than the ratio found in meandering river which is usually less than 10. But it is less than the ratio in braided river which is usually about 40. The width and depth shows as an exponential relation (Fig.9～Fig.10).

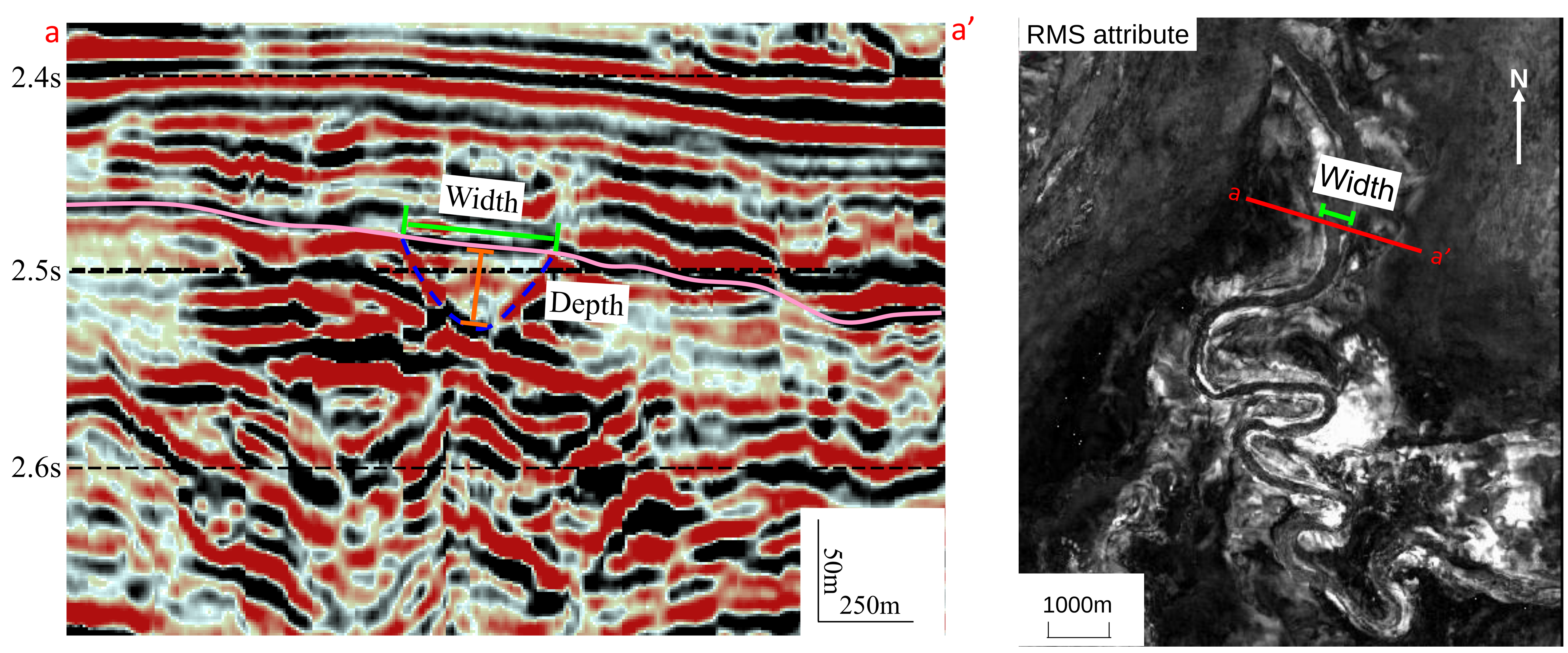


Fig.9 Measurement method of width and depth of single channel

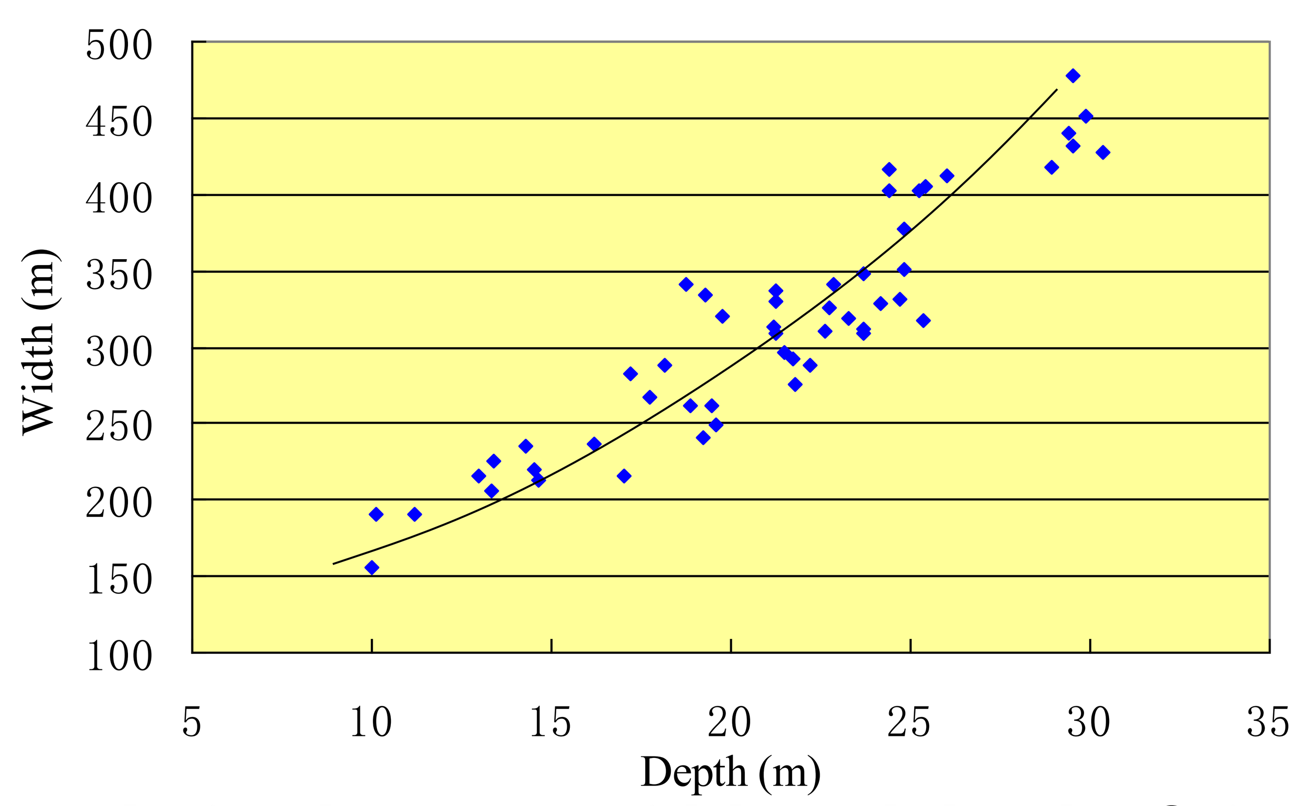


Fig.10 Relation between width and depth of single channel