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Research Article

Fine Characterization of Sand Body in the Front of the Fluvial Delta: Taking the VII Oil Group of N_2^1 Reservoir in Gasikule Oilfield as an Example

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Taking the VII oil group of N_2^1 reservoir in Gasikule Oilfield as an example, the sedimentary time unit was divided into the barrier layer, interbed, and sand bed by analyzing the sedimentary system and sand body development model in this paper. The single sand body was analyzed for the sand bed time unit. The residual muddy intercalation period division theory was proposed for the first time to divide the sedimentary periods of the sedimentary time unit of the sand bed. Finally, a new "sandwich" layer point coincidence modeling technology was proposed to characterize the sedimentary time units of a barrier layer accurately and interbed and finely describe the sedimentary time unit of the multiperiod sand bed.

1. Introduction

More and more old oilfields gradually enter the middle and later stages of development in China, especially that some oilfields have entered the stage of enhanced oil recovery, so it is very urgent to improve the understanding of geological bodies of reservoirs continuously. At present, there are two methods for fine analysis of geological bodies of the reservoir, i.e., sand body architecture anatomy and single sand body description. The reservoir architecture concept originated from fluvial architecture proposed by Allen in 1977 [1]. Based on previous studies, Miall defined reservoir architecture [2], interface level, architecture unit, etc. At present, there is no unified understanding of the single sand body concept in academia. Wu et al. think that a single sand body is the sand body with a single microfacies origin [3]. This concept is mainly from the perspective of sand body genesis. Li thinks that a single sand body refers to the sand body, which is vertically and planarly continuous but separated from the upper and lower sand bodies by mudstone or impermeable interbeds [4]. The concept emphasizes the connectivity of sand bodies [5–16].

Based on the theories proposed by the previous researchers and the actual characteristics of the study area, the single sand body was redefined, and the new methods for period division and three-dimensional (3D) geological modeling and characterization were proposed for the mouth bar sand body at shallow lacustrine fluvial-dominated delta front. The methods can describe the multistage sand bodies during sedimentation very well and depict the argillaceous intercalation between different sand bodies. This paper is aimed at innovatively providing a new method for the period division of complex sand body and exploring the method for characterization of the multiphase sand body by a 3D geological model. This study is of great practical value to finely research the reservoir geology, especially depiction of the multiphase composite sand body.

2. Geological Setting

The Gasikule Oilfield is located in the west of Qaidam Basin in China (Figure 1). Neogene reservoirs mainly include structural reservoir and lithologic reservoir and belong to the tertiary structure on the No. 1 fault nose zone in the Hongliuquan-Yuejin Area in the Gasikule fault depression subregion of the Mangya depression region. The southwestern Qaidam Basin has a high content of unstable heavy minerals, which reflects the characteristics of proximal transport and deposition. In the southwest Qaidam Basin, there are three main provenances: (1) Altun provenance in the north, (2) Qimantage provenance in the south, and (3) Alar provenance in the west (mixed provenance of Altun Mountain and East Kunlun Mountain). That was further verified by Li et al. (2015) by studying the Caenozoic heavy mineral distribution characteristics in the southwest of Qaidam Basin [17]. The Gasikule Oilfield, located in the middle of Southwestern Qaidam Basin, has a complicated provenance system, which is affected by three provenances.

The river-floodplain facies mainly developed in the early Paleogene (Paleocene), and delta plain facies mainly developed in the early Oligocene in northwestern Altun Mountain of the Gasikule area. After that, with increasingly violent tectonic movement in the area, the surrounding mountain system gradually uplifted, and the lake water gradually intruded into the Gasikule area. In the late Oligocene and early Miocene, the lake water intruded all the area, resulting in the main development of shore-shallow lake facies. In the late Miocene, the lake water retreated from the area, and the braided river delta front facies developed. In the middle and late Pliocene, the braided river delta front subfacies gradually changed into braided river delta plain subfacies so that all the lake water retreated and braided river deposits developed at the end of Pliocene.

The N_2^1 reservoir of the Gasikule Oilfield deposited in the Cretaceous-Paleogene in the whole basin and formed a braided river-braided river delta system under dry climate conditions. There are wide belts of fluctuation in the lakes and rivers, while there are relatively small stable lake area and deep lake area. The research object mainly develops into a shallow lacustrine fluvial-dominated delta deposition system. The VII oil group mainly develops into the delta front subfacies. The microfacies include the underwater distributary channel, mouth bar, interdistributary bay, and sheet sand. The main sand body is the mouth bar sand body, which is a highly constructional delta deposit (Figure 2).

Based on the lithology, the reservoir mainly contains feldspathic sandstone and feldspathic lithic sandstone and minorly lithic arkose. The rock debris mainly includes igneous rock debris. In terms of grain size, the sandstone contains 48.5% coarse and medium sand, 36.2% fine sand, and 24.3% silt. Carbonate cement mainly includes calcite and dolomite. Clay mineral is mainly an illite smectite mixed layer. The clastic debris mainly contains angular and subangular particles. Besides, the particle sorting is poor, and the particles are mainly contacted with one another by points and lines and mainly cemented by pores.

3. Methods

3.1. Division of Sedimentary Time Units. The sedimentary time unit refers to the codeposition formed under physical and biological actions under the same sedimentary background. It is believed in the previous studies that a sedimentary time unit of fluvial facies strata corresponds to a fluvial period, i.e., from the birth to death of a river [19–21]. For this study, the main sand body is the mouth bar sand body, so the vertical performance of the sedimentary unit is from the birth to death of a mouth bar sand body. The traditional member boundary in the study area is determined according to the natural gamma-ray relative maximum value and thus often located in the middle of mudstone, not at the lithology interface. Usually, there is sandstone in the middle and mudstone in the upper and lower parts of the member. Generally speaking, a member includes one layer of sand in the middle and two layers of mud in the upper and lower parts of the member. Although such a division method makes the division boundary clearer, it always results in the existence of mud top and bottom in most of the sand bodies in the member. Such a member is not a single sedimentary time unit. Therefore, it is necessary to refine the existing layering system in order to divide the sedimentary time unit and achieve the practicability of the layering system without damage to the original system.

In this study, the members divided by the existing layering system are subdivided into three sedimentary time units: (1) barrier layer sedimentary time unit, (2) sand bed sedimentary time unit, and (3) interbed sedimentary time unit. Taking the member VII-15 of Y105 well in the study area as an example, the last division of members cannot directly describe the interbed of two sand bodies, but the VII-15 members are divided into five sedimentary time units (Figure 3) during the current division. After the division of the sedimentary time unit of the members in a single well in the whole area, all the members in the whole area were checked through an equal elevation method, slicing method, curve shape method, etc. The division results of sedimentary time units will provide a basis for the fine study of a single sand body in a later stage.

3.2. Single Sand Body Analysis of Sand Bed Time Unit

3.2.1. Traditional Definition of Single Sand Body. It is found from the research results in recent years that there is no consensus on the definition of a single sand body in academia [3–16]. From the perspective of sand body genesis, the researchers represented by Wu SH think that a single sand body is a single microfacies sand body. However, From the perspective of sand body connectivity, Li thinks that a single sand body is the sand body which is vertically and planarly continuous but separated from the upper and lower sand bodies by mudstone or impermeable interbed. In my opinion, the two definitions have their theoretical significance.

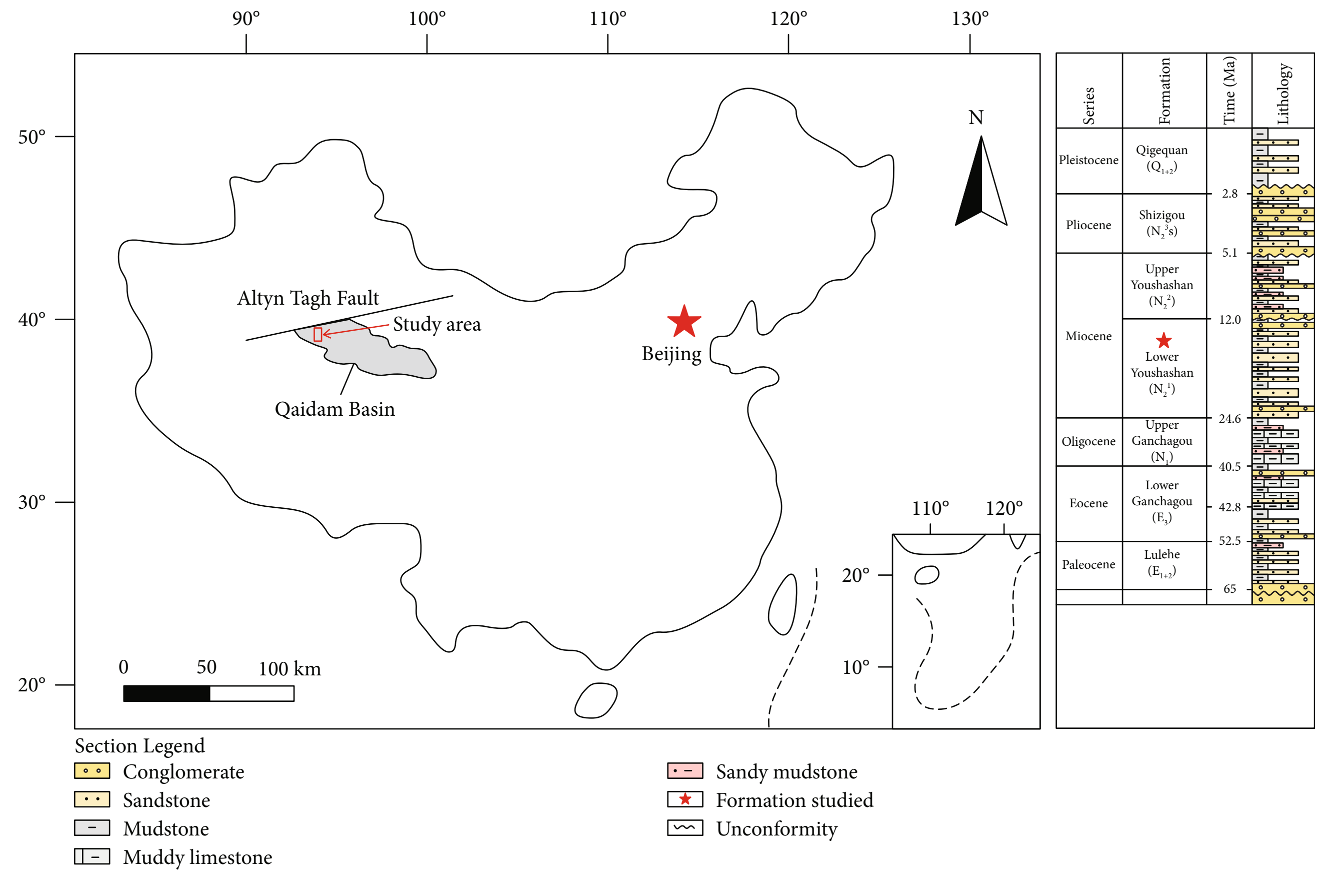


FIGURE 1: Location and lithological and stratigraphic system of the study area (modified from [18]).

The former is mainly controlled by autocyclicity, while the latter is mainly controlled by allocyclicity. From the perspective of sedimentary cyclicity, the autocyclicity is very random, while the allocyclicity is regional. Comparatively speaking, the sand bodies in the study area are thin, diversified, scattered, and miscellaneous, showing that the sand body development is significantly controlled by autocyclicity. Moreover, from the perspective of production performance analysis, the developers are focused on the sand body connectivity. Thus, the definition of a single sand body proposed by Li was adopted in this paper.

3.2.2. Sand Body Development Model of Shallow Lacustrine Fluvial-Dominated Delta. The sedimentary system in shallow lacustrine fluvial-dominated delta develops in the research object in this paper, and delta front subfacies develop in VII oil group subfacies. The sand bodies of such sedimentary systems are divided into the distributary channel sand body and distributary bar sand body. The researchers both at home and abroad have performed a lot of detailed studies on the development mode of such delta sand bodies and achieved fruitful results.

A series of shallow deltas form in the modern Mississippi River delta first and advance through the shallow water shelf to the east of the modern delta and the west of the Mississippi River. The research results from Frazier (1969) show that the Mississippi River delta is composed of four large delta complexes, which are composed of 15 lobes; these lobes have been gradually abandoned in the past 6000 years, so a large number of distributary channels pass through the delta plain and frequently bifurcate along the coast; these bifurcated distributary channels form a series of closely distributing river mouth bars, which are combined with one another in the shoreline to form large-scale composite sand bodies (Figure 4). The measurement of the radiocarbon age of peat layers between different delta complexes shows that the lobes in a delta complex are often contemporaneous, indicating that the bifurcated distributary channel systems are contemporaneous, and some of the complexes are contemporaneous, indicating that the total flow of the fluvial system distributes in each complex. Such study also reveals that when one lobe is abandoned, another lobe may be forming, developing to its peak stage, and beginning its abandonment stage [22].

Previous research results show that as the river to basin water depth ratio increases (the river mouth water body becomes shallower), the friction force between water flow and bottom shape increases, conducive to the formation of the river mouth bar and the diversion of the river channel. When the river to basin water depth ratio is greater than or equal to 1 at a constant unloading rate, the river channel cuts down into the front delta deposit and forms the topset dominated delta. When the river to basin water depth ratio is less than 1, the foreset dominated delta forms (Figure 5) [23–27].

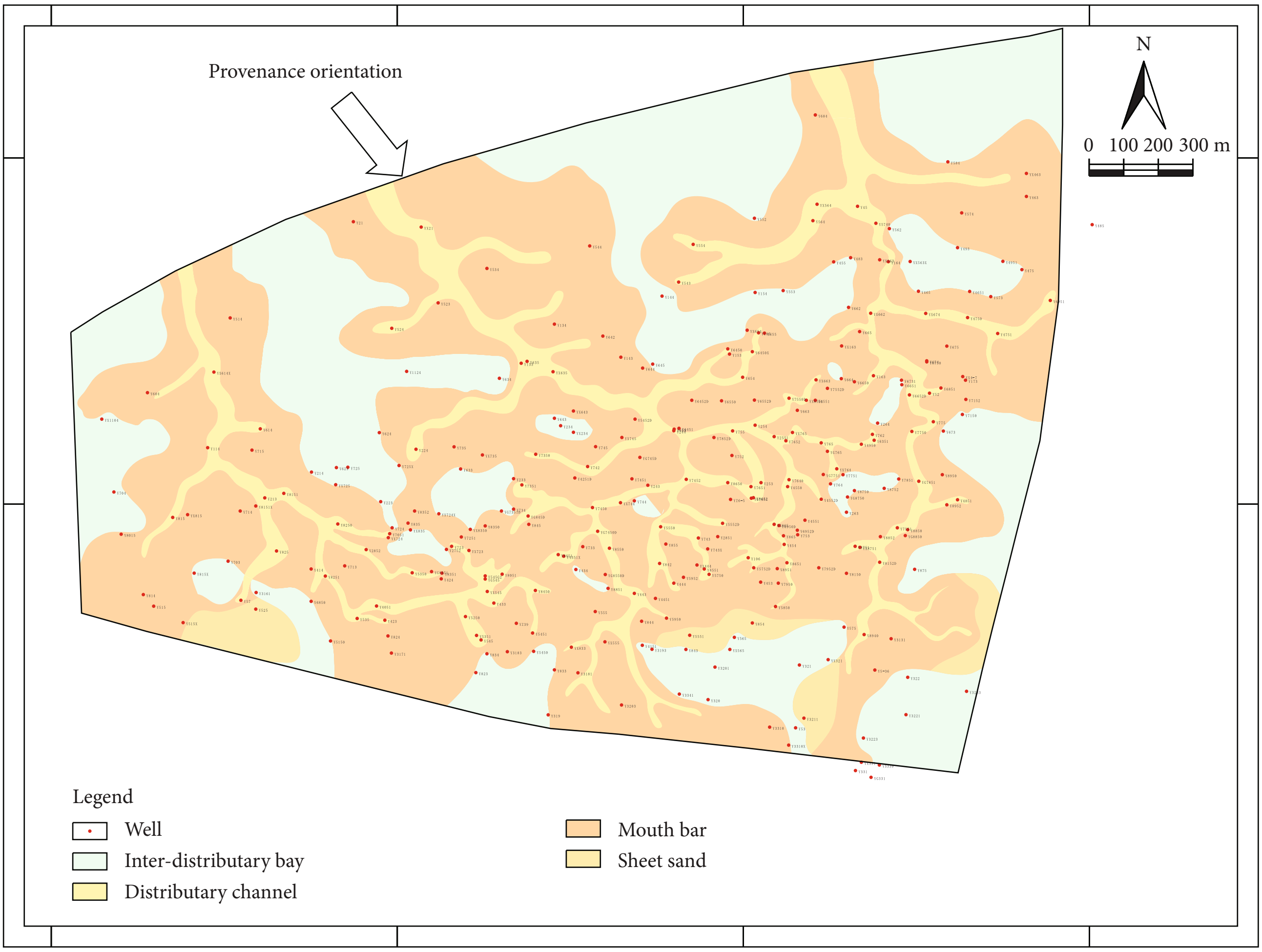


FIGURE 2: Map of sedimentary microfacies of VII-15 members of N_2^1 reservoir in Gasikule Oilfield.

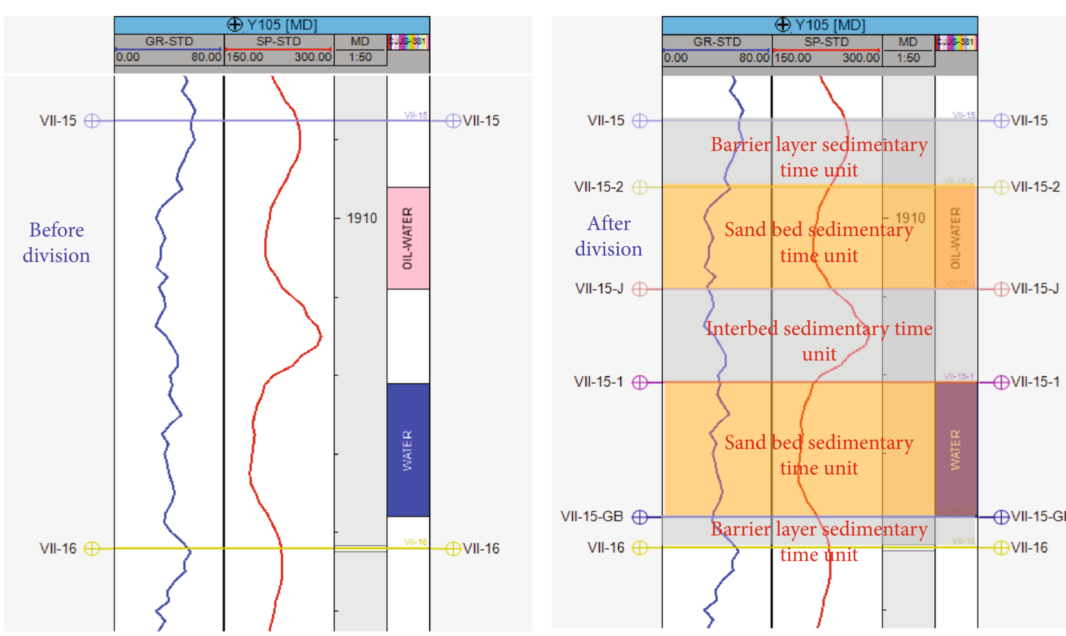


FIGURE 3: Division results of sedimentary time unit (Y105 well).

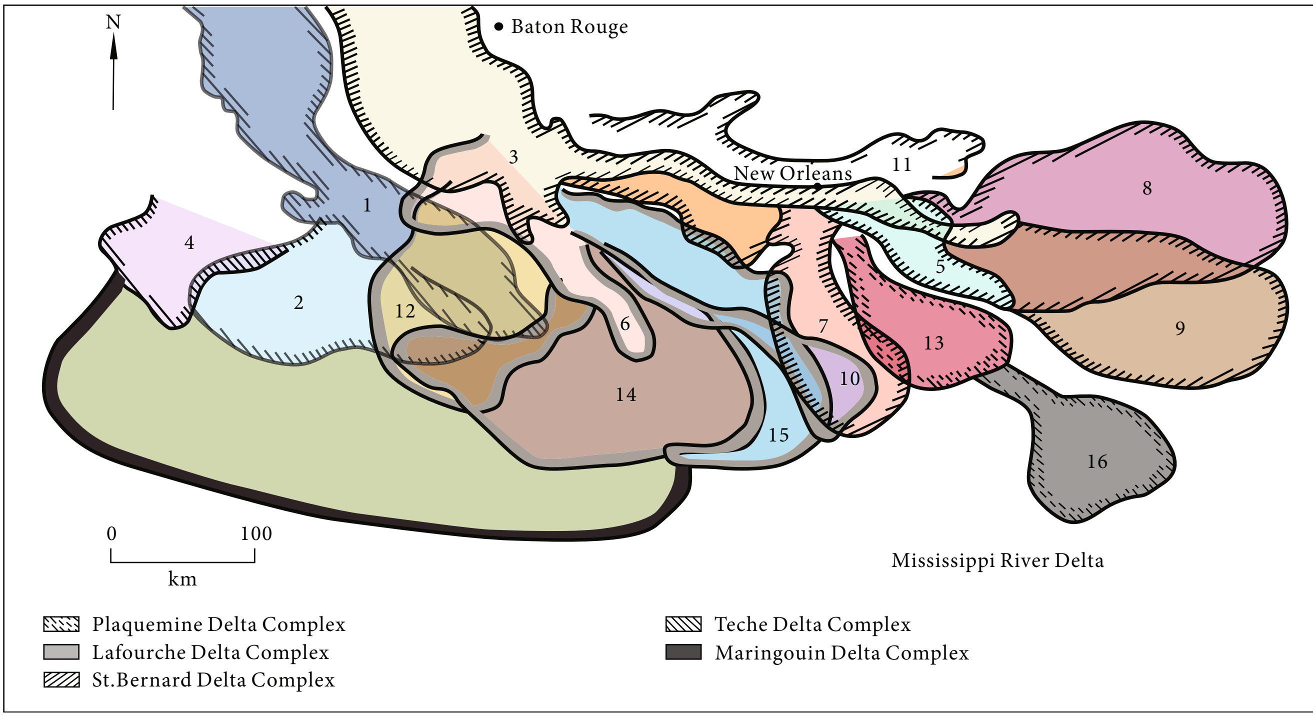


Figure 4: Regional distribution of modern Mississippi River deltas and lobes (Frazier 1967; Fisher & McGowen, 1969; [22]).

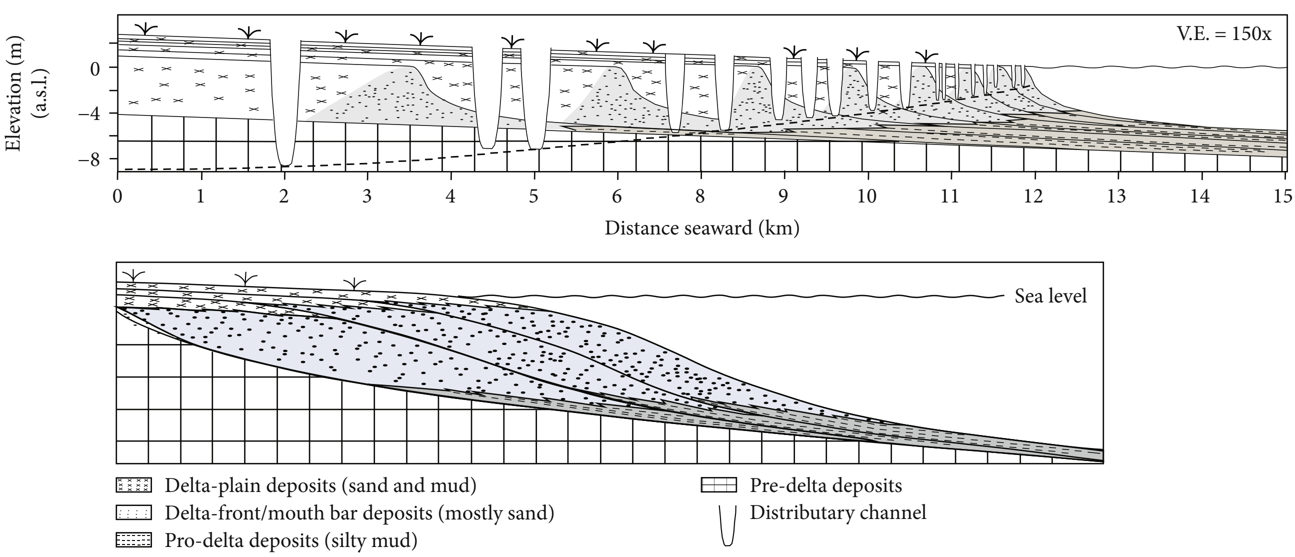
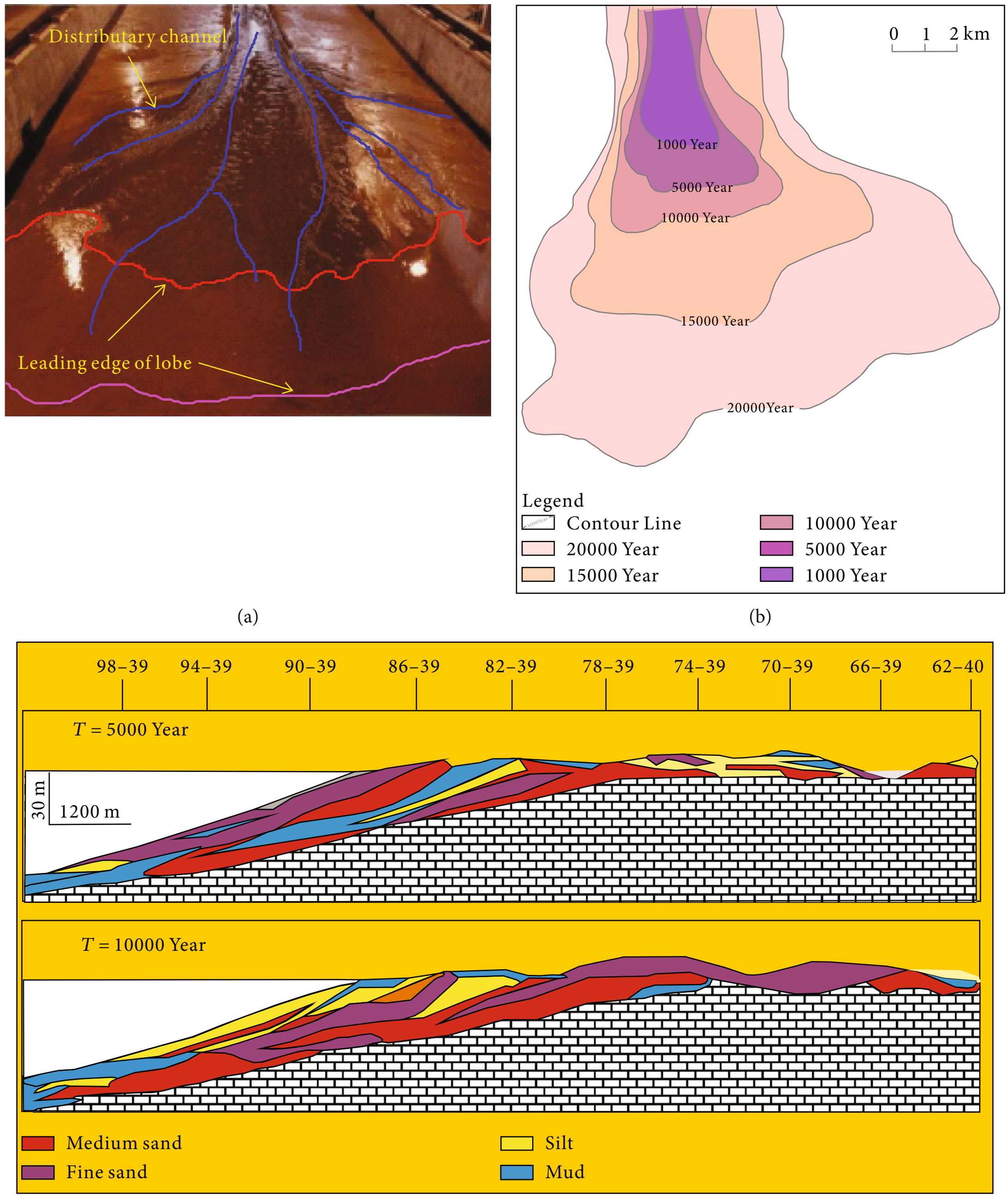


Figure 5: Profiles of topset and foreset dominated deltas (Edmonds, 2011).

Zhang [28] simulated the laboratory tank of the shallow delta with the river to basin water depth ratio below 1. The experimental area was underwater and 2.5 m below the water surface at the beginning of the experiment. As the experiment proceeded, the distributary channel continuously extended forward, and the delta gradually advanced (Figure 6(a)). From the perspective of time scale during simulation, the area of the delta complex lobe gradually increased over time (Figure 6(b)). The longitudinal profiles of the simulation results show that the delta sand body obtained during simulation has no obvious three-layer structure and does not belong to typical Gilbert type delta; neither topset nor bottomset develops, and the development of the sand body is mainly controlled by the foreset (Figure 6(c)) [28].

The previous research results and the sedimentary characteristics of the research area show that the research area is highly constructional delta deposit; the sand body mainly develops in the foreset mode, the sand body is mainly distributary bar sand body, and the main sand body is mouth bar sand body. When the delta deposit advances into the lake basin, the excessive expansion of the channel system diverts



(a) (b) (c)

Figure 6: Physical simulation results of delta (Zhang [28]). (a) Photo of delta front sand body obtained from simulation; (b) contour line of delta front sand body development; (c) profile of delta front sand body provenance.

the alluvial channel or distributary channel, leading to the abandonment of an old delta or lobe and the formation of a new delta or lobe in another place. The delta will stop or significantly reduce the speed of advancement to the lake basin when the supply decreases, whereas the delta will continuously advance into the middle of the lake basin when the supply increases.

3.2.3. Definition of Single Sand Body in This Paper. According to the previous definition of single sand body and the characteristics of sand body development in the research area, the single sand body in the VII oil group of N_2^1 reservoir in Gasikule Oilfield is defined as the mouth bar lobe complex, which is upwards and downwards sealed by mudstone and inside which there are often multiperiod lobes between which the connectivity exists, from the perspective of sand body connectivity.

According to the characteristics of the interbed, the mouth bar lobe complex can be further subdivided to give a single mouth bar lobe. Therefore, the single sand body in the research area can be further divided into two levels (Figure 7).

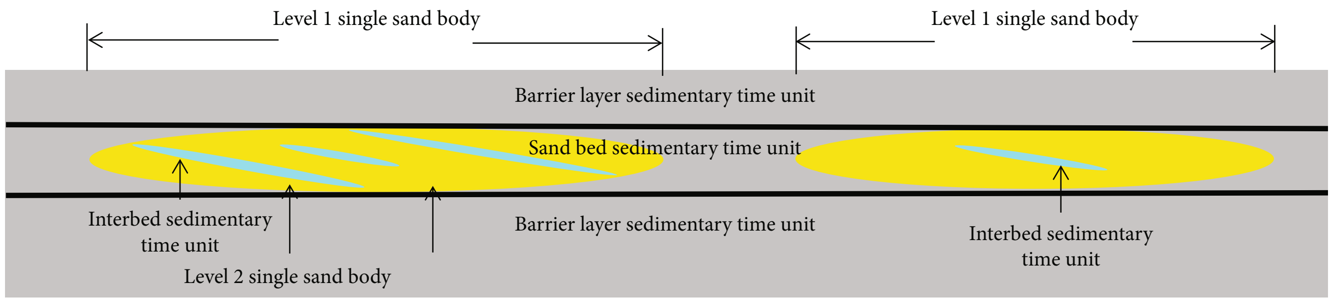


Figure 7: Conceptual model of single sand body.

Level 1 single sand body (mouth bar lobe complex) is controlled longitudinally by interbed and transversally by interdistributary mudstone, with strong sedimentary regularity, definite interpretation, regional scale, and transversal facies change.

Level 2 single sand body (single mouth bar lobe) is three-dimensionally controlled by regional interbed, both ends of which are connected with the upper and lower barrier layers to form a seal.

It is believed through this study that the two levels of single sand bodies are mainly controlled by a sedimentary cycle, and Level 2 single sand body is controlled by autocyclicity. Beerbower (1965) puts forward the concept of autocyclicity [29] and pointed out that autocyclicity refers to the periodic deposition and erosion of the sedimentary system, including channel migration, channel diversion, and sand bar migration, to balance its energy when the external conditions (tectogenesis, provenance supply, and climate change) are unchanged. Maill (1996) believed that such autogenetic stratum never occurs cyclically, and the most common autogenetic stratum forms by crevasse deposition and river channel migration [30]. The range of autocyclicity depends on the sedimentation of the sedimentary system and is often limited to the microfacies of the sedimentary system [31]. The sedimentary strata formed by autocyclicity have poor transverse continuity and short longitudinal duration. However, Level 2 single sand body (single mouth bar lobe) is controlled by autocyclicity. Such a feature is reflected by the lithology of the upper and lower parts of the sand body. Besides, Level 2 single sand body always has no continuous and stable mudstone layer. Based on its definition, the upper and lower parts of Level 1 single sand body have relatively continuous and stable mudstone barrier layers. Such mudstone barrier layer is often related to tectogenesis, change of sediment supply rate, periodic change of climate, and change of lake level and controlled by allocyclicity.

3.2.4. Sand Body Period Division Based on Residual Muddy Intercalation. The sand body is always formed in many sedimentary periods and intermittent periods, not in one period. The sand is mainly formed and three-dimensionally distributed in lenticular shape due to the strong hydrodynamic force and coarse deposit in the sedimentary periods, and the mud is mainly formed in the intermittent periods due to weak hydrodynamic force. The mud forms the interbed between sand beds. According to the interbed combination law and its relationship with provenance direction, the sand body deposition modes can be divided into progradation, retrogradation, lateral accretion, and aggradation. Thus, the four deposition modes and the lenticular shape of sand bodies become the main basis for the division of sand body periods.

In this study, the method for division of the single sand body period using the residual muddy intercalation as the period identity was innovatively proposed as follows.

(1) Muddy Intercalation Formation Mechanism. The muddy intercalation is the residue after superimposing sand bodies with the same period and different facies and with the same facies and different periods. The interbed is the residue of incomplete contact between two sand bodies. The interbed between two completely contacted sand bodies (with the same or different periods) should be cut out completely. The interbed discovered now is located at the junction of two sand bodies. The position of the interbed can be used as the boundary of the contact between sand bodies. The degree of interbed development can reflect the degree of early sand body transformation to the late sand body. The higher the transformation degree is, the less developed the interbed is. On the contrary, the higher degree of interbed development indicates that the sand bodies are incompletely or not transformed in the two periods. The residual interbed distribution position indicates the junction of two single sand bodies.

It can be seen from Figure 8 that when the lake basin gradually retreats, the delta front mouth bar lobes advance towards the lake basin. Profile 1 shows that two single mouth bar lobes are separately distributed in plane and separated by the front mud; when the lake shoreline further retreats, the distributary channel continues to advance on the lobes in the previous period; it is possible to continue to use the channel in the previous period to cover the old one with new lobes, or it is possible to continue to develop new lobes in a new distributary channel; as the shoreline continues to retreat towards the center of the lake basin, the delta front sand body continues to advance towards the center of the lake basin; the lobes in the next period aggrade on the previous period in the form of nappe cutting at the overlapping position of multiperiod lobes; in the case of complete nappe cutting, the front mud at the upper part of the lobe formed by autocyclicity is eroded, so the muddy intercalation of the

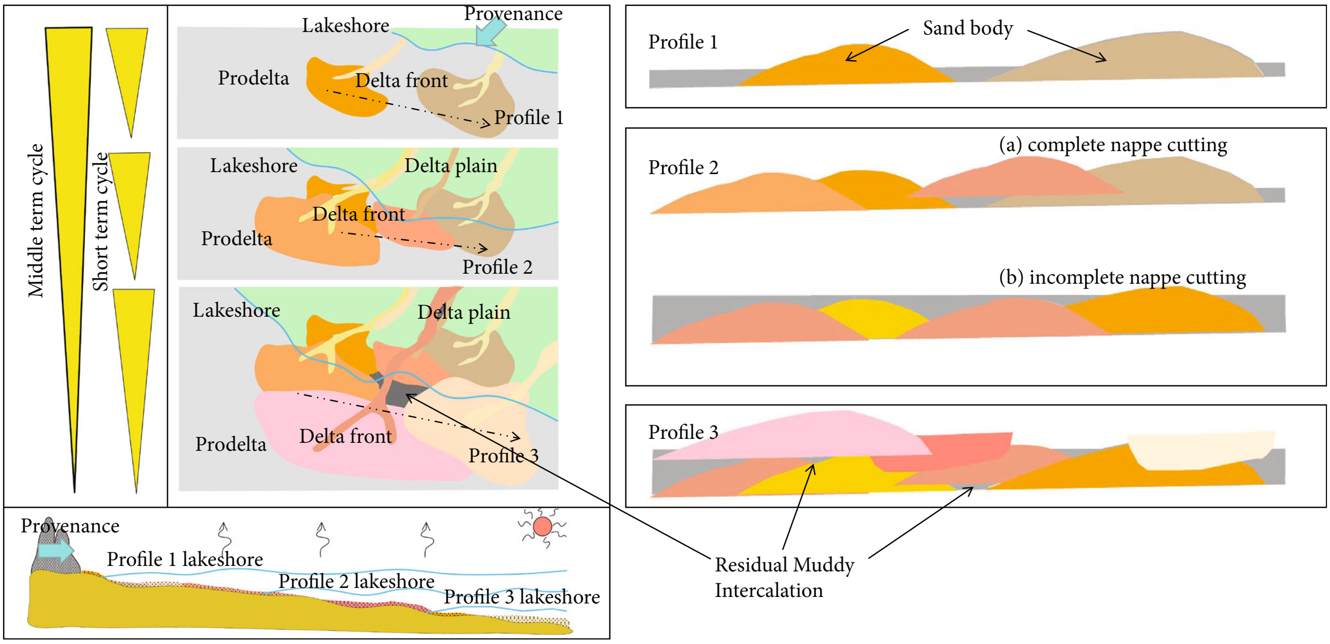


Figure 8: Formation mechanism of muddy intercalation under the background of lake regression.

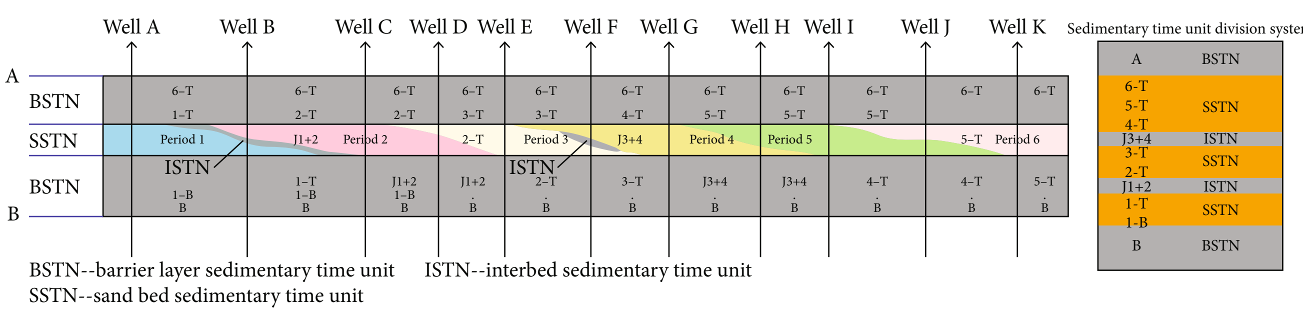


Figure 9: Schematic diagram of "sandwich" layer point coincidence modeling technology.

lobes in the two periods will disappear, but the lobes directly contact with each other (Profile 2-a); on the contrary, the muddy intercalation formed by autocyclicity will retain in case of incomplete nappe cutting (Profile 2-b).

Based on the analysis, it is believed that the interbed distributes at the contact between multiperiod lobes. By identifying the interbed distribution, we can divide the period boundaries of different lobes. The number of muddy intercalations identified longitudinally in a single-member reflects the development characteristics of multiperiod sand body superimposition.

3.3. "Sandwich" Layer Point Coincidence Modeling Technology. The 3D modeling technology is widely used in the geological industry [32–37]. Since 3D geological modeling technology appeared in the 1980s, it has been rapidly developed and widely applied in the oil and gas field. With oilfield development, the higher accuracy of the 3D geological model is required. The research results of 3D geological modeling play an increasingly important role in comprehensive adjustment and EOR in oilfields and have become a critical support basis for decision-making and deployment [35, 38–48]. The pilot gas flooding experiment has been carried out in Gasikule $E_3^{\ 1}$ reservoir of the Qinghai Oilfield. It is very urgent to accurately describe the spatial distribution characteristics of the barrier layer and interbed time units.

According to the published information, there are no relevant research methods or results for 3D geological modeling of the barrier, interbed in shallow lacustrine fluvial-dominated delta front and multiperiod prograded sand body. According to the characteristics of the existing layering system of the Gasikule $N_2^{\ 1}$ reservoir in Qinghai Oilfield, a new method for modeling of "sandwich" layer point coincidence modeling technology was proposed. Based on the accurate description of interbed distribution, this technology can three-dimensionally characterize the multiperiod sand body time unit.

For the so-called "sandwich" layer point coincidence modeling technology, there are sand bed time units and interbed time units in different periods between two barrier layer time units located at the top and bottom of the member, respectively, so the member looks from the profile like a

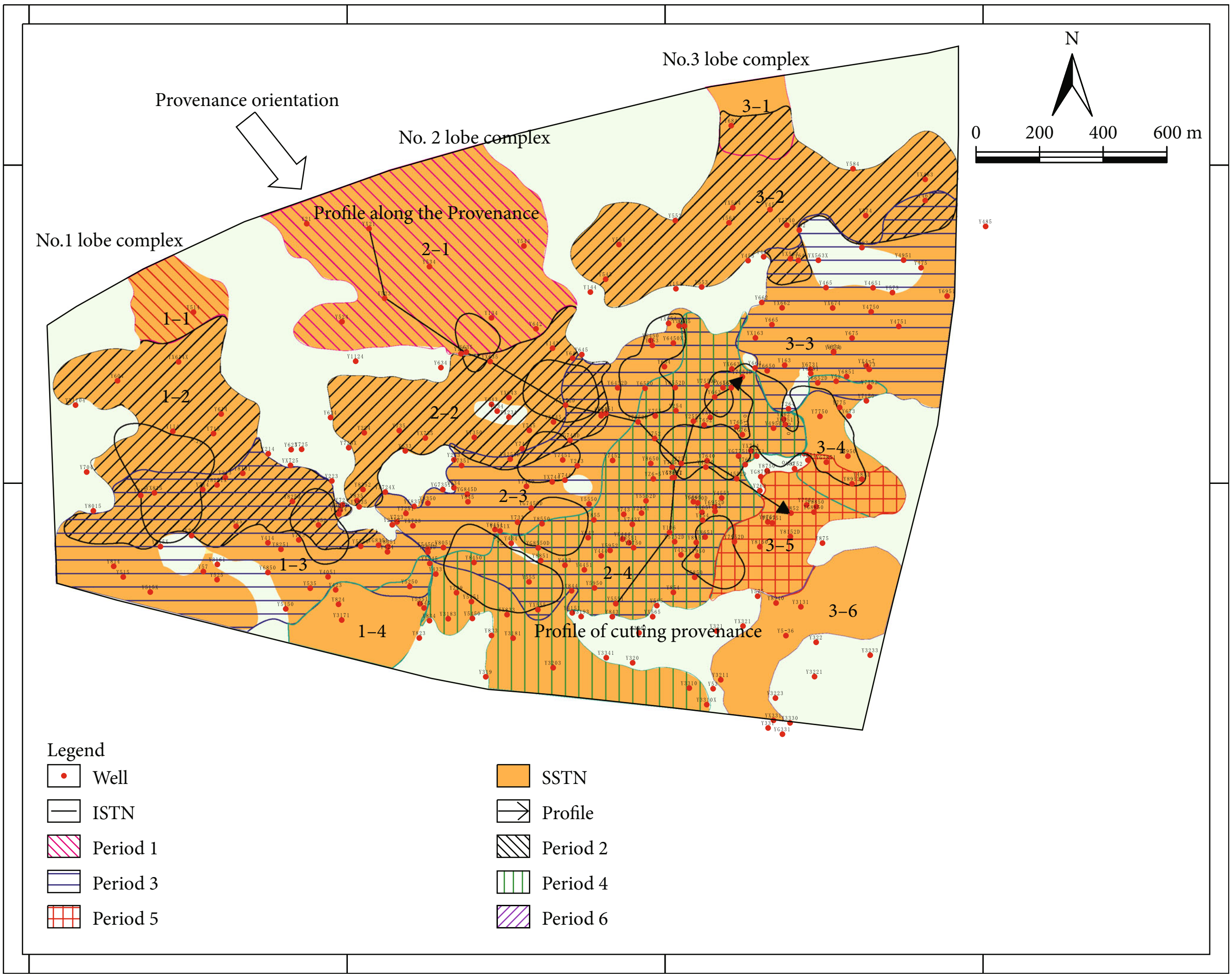


Figure 10: Profile of single sand body in VII-15 member.

sandwich (Figure 9). The technology includes the following main steps: (1) establishment of the layering system corresponding to the sedimentary time unit, (2) use of the layer point coincidence method for the sedimentary time unit with zero thickness to unify the layering system in the whole region, (3) zoning of the whole area according to the division results of the sand bed sedimentary unit period, and (4) determination of the coincidence point layers in different regions to three-dimensionally characterize the multiperiod progradation of the sand bed sedimentary unit.

4. Results and Discussion

4.1. Single Sand Body Period Division Results. The method for division of single sand body periods is illustrated by taking the sedimentary time unit of the VII-15 member as an example.

To divide the periods, the lobe complex is identified for Level 1 single sand body first, and then, the sand body profile along with the provenance and perpendicular to the provenance is made for different lobe complexes. According to the distribution of the sand body, especially the distribution characteristics of the sand body along with the provenance, the sand bodies grow under progradation in the research area. Thus, the contact relationship between sand bodies should be determined by means of lenticular sand body progradation in order to analyze the overlapping relationship between sand bodies.

The VII-15 member is planarly composed of three lobe complexes in the underwater distributary channel. The single sand body period (single period lobe) is analyzed by drawing the sand body profiles in two directions of each lobe complex (Figure 10).

The single period lobe is Level 2 single sand body studied in this paper. No.2 lobe complex is taken as an example. No.2 lobe complex is the main sand body of the VII-15 member. From its plane distribution, No.2 sand body mainly distributes in the NW-SE belt. The profile along the provenance shows that the sand body develops most from YX635 to Y4552D mainly by means of bar progradation. The profile passes through the underwater distributary channel and mouth bar sand along with the provenance. The residual

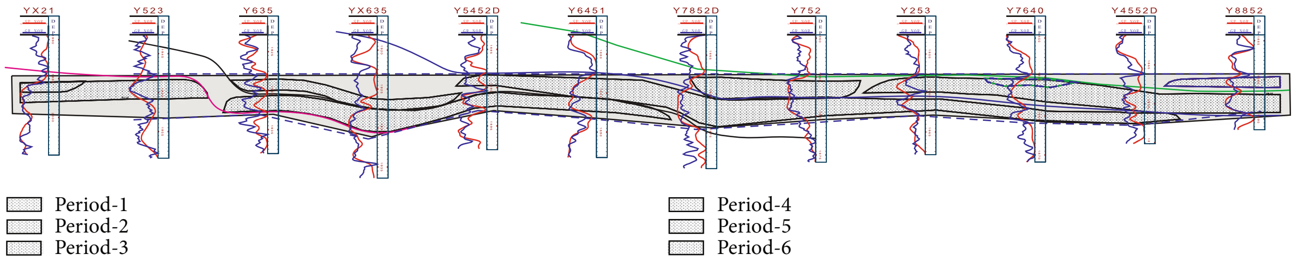


Figure 11: Profile along the provenance of single sand body of No. 2 lobe complex in VII-15 member.

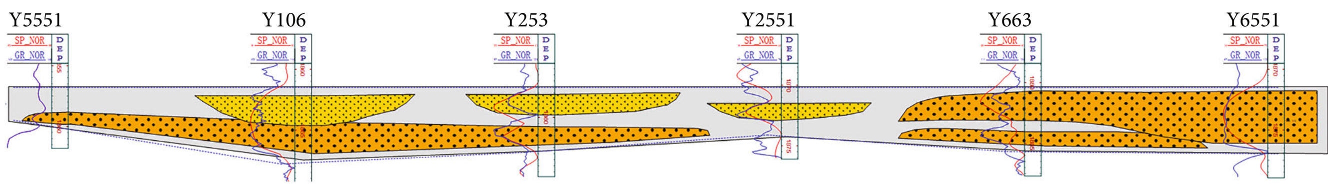


Figure 12: Profile of cutting provenance direction of the single sand body of lobe complex No. 2 in member VII-15.

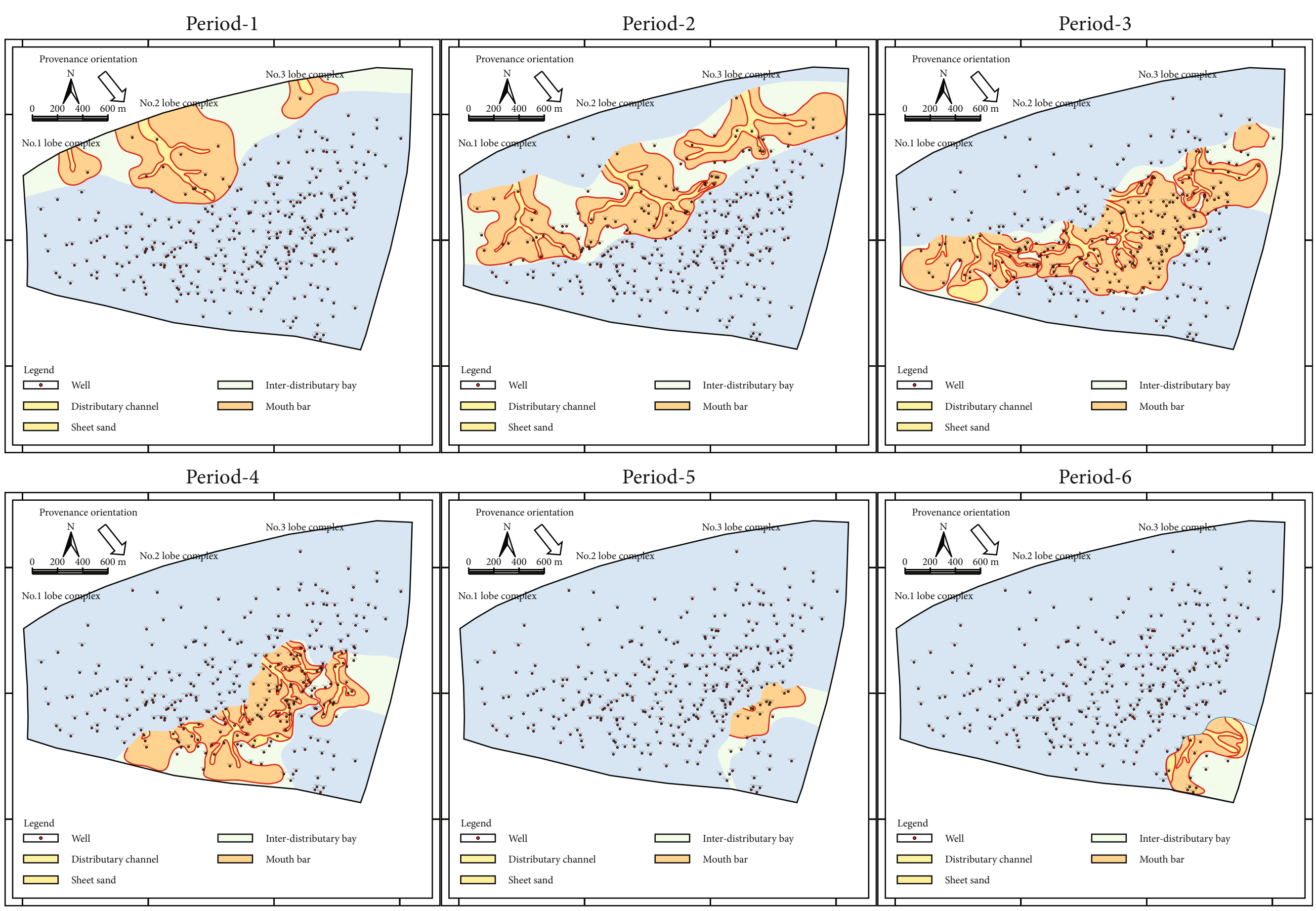


Figure 13: Plane view of division of sedimentary microfacies period in VII-15 member.

muddy intercalation distribution shows that residual muddy intercalation occurs in Y635 well, Y253 well, Y7640 well, and Y8852 well. According to the methods summarized in this paper, the periods were divided, and the prograded sand bodies were combined mainly near these wells. To determine whether different microfacies are in the same period or not, the plane distribution characteristics of microfacies are mainly taken into account. To study the morphological characteristics of the planar facies on the profiles, especially the combination of underwater distributary channel facies and

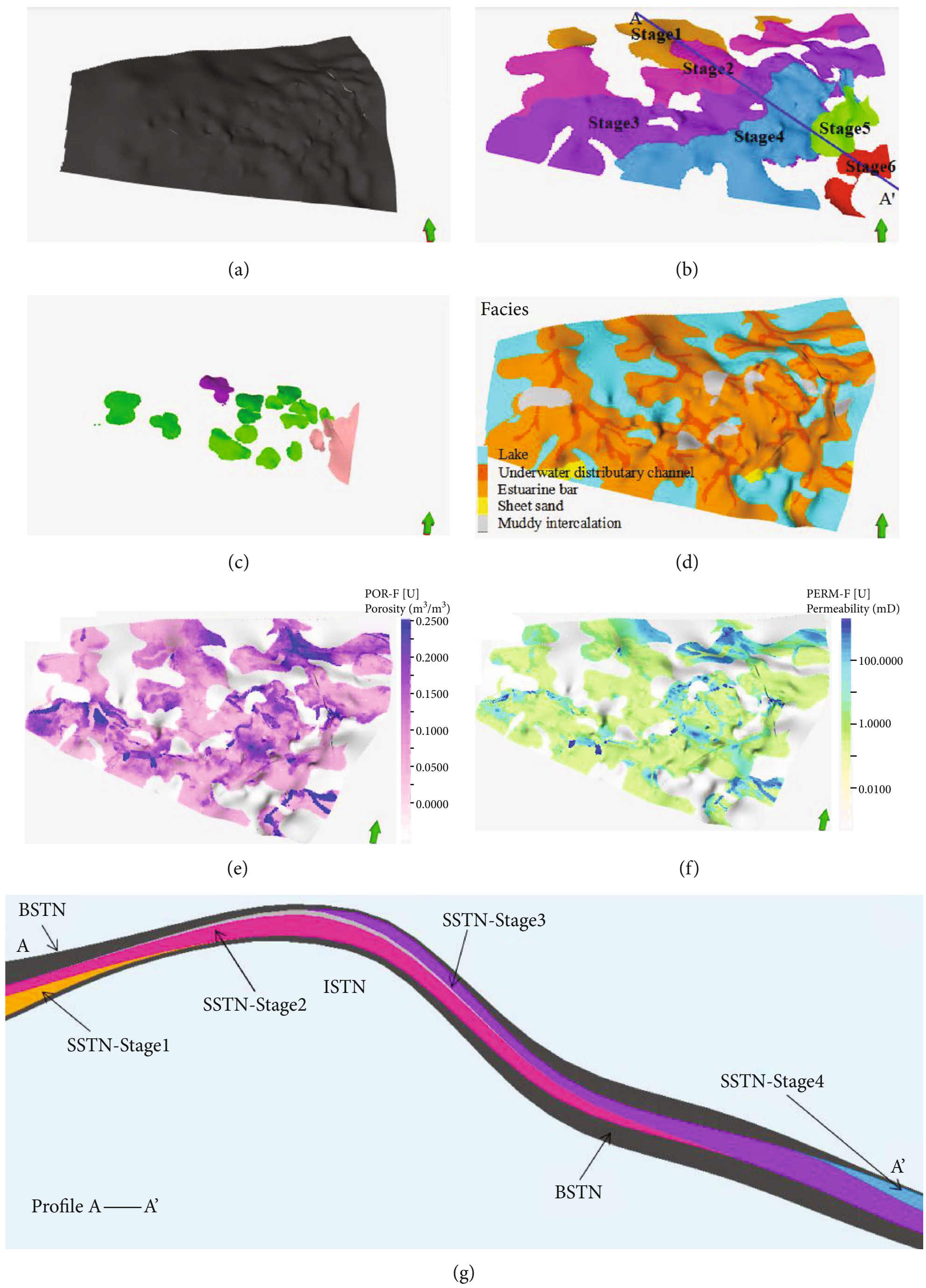


Figure 14: Result of "sandwich" layer point coincidence modeling technology for VII-15 member: (a) barrier layer sedimentary time unit; (b) sand bed sedimentary time unit; (c) interbed sedimentary time unit; (d) facies model; (e) porosity model; (f) permeability model. (g) The section shown in (b).

mouth bar microfacies, the underwater distributary channel along the provenance must be regarded as the provenance supply channel of the mouth bar sand body. The lobe complexes in the No. 2 underwater distributary channel are divided into five periods (Figure 11).

In the profile perpendicular to the provenance, the sand bodies mainly vertically aggrade. From the profile, the sand bodies are not horizontally overlapped, especially near Y2551 well. The reason why the sand bodies are connected on the plan is that the member-scale sand body map is drawn by superposition of multiperiod sand bodies (Figure 12). According to the previous drawing experiences, the sand body in the Y2551 well is not disconnected with the sand body in an adjacent well during the drawing of the good profile without consideration of microfacies and sedimentary characteristics of the sand body. In this study, it is believed that the sand body in Y2551 well does not communicate with the sand body in the adjacent well because of the following:

(a) The sand body in the VII-15 member in Y2551 well has a small thickness. According to the characteristics of logging curves, the sand body is the underwater distributary channel sand body; the upper and lower parts of the adjacent Y253 well are the channel sand body and mouth bar sand body, respectively. Considering the elevation and profile perpendicular to the provenance, it is believed that the sand bodies in Y2551 well and in the upper part of Y253 well are in the same sedimentary microfacies, but never communicate with each other; and the sand bodies in Y2551 well and in the lower part of Y253 well are in different sedimentary microfacies and different periods and never communicate with each other

(b) If the sand body in the VII-15 member in Y2551 well is the provenance supply channel of the mouth bar sand body in the previous two periods in Y663 well, the symmetrical sand bodies with similar properties should exist in Y253 well. In terms of elevation, the sand body in Y2551 well and the sand body in the upper part of an adjacent well should be in the same period. However, the sand bodies at both sides of the adjacent well have different properties, so it is believed that the underwater distributary channel sand body of the VII-15 member in the Y2551 well is not the provenance supply of the mouth bar sand body in the upper part of Y663 well, resulting in no communication

According to the method for division of the residual muddy intercalation period, one Level 1 single sand body was identified in the VII-15 member and composed of three lobe complexes, and Level 2 single sand body 14 was further identified. No.1 and No.2 lobe complexes were composed of four Level 2 single sand bodies, respectively, and No.3 lobe complex was composed of six Level 2 single sand bodies. According to the period division results, the corresponding plane distribution of the sedimentary microfacies is plotted and shown in Figure 13.

4.2. Application Example. Taking the VII-15 member in the research area as an example, the VII-15 member has the average thickness of 4.94 m, average thickness of sand bed time unit of 2.65 m, minimum sand bed thickness of 0.8 m, average thickness of interbed time unit of 1.1 m, and minimum interbed thickness of only 0.3 m. The conventional modeling method shows that if you want to accurately describe the longitudinal 0.3 m interbed time unit, the longitudinal mesh spacing should be less than 0.3 m so that the number of meshes in the model greatly increases. That is a big challenge for either computer hardware or subsequent reservoir numerical simulation. The "sandwich" layer point coincidence modeling technology can be used to effectively avoid excessive meshes because the longitudinal characterization accuracy of the technology depends on the division accuracy of sedimentary time units, not longitudinal mesh spacing. Thus, this technology accurately describes the reservoir with fewer grids and reduces the demand for model operation. In addition, this method is so flexible as to develop the prograded, laterally accreted, retrograded, and aggraded sand bodies. Aggradation and progradation mainly develops in the sand body sedimentary time units of the VII-15 member.

According to the above-mentioned division results of sand bed sedimentary time unit, the "sandwich" layer point coincidence modeling technology is used to model the sedimentary time unit of the VII-15 member. After the division of the sedimentary time unit of the upper and lower barrier layers of the member, the interbeds in each area are counted and finally numbered. Furthermore, the sand bed sedimentary time units in six periods are numbered. Finally, the layer coincidence points are set in different regions. The VII-15 member is longitudinally divided into six periods of sand bed sedimentary time unit, three periods of interbed sedimentary time unit, and two barrier layer units, with a total of 13 members. For the distribution of different sedimentary time units, see Figure 14. The longitudinal profile shows that three types of sedimentary time units can be well characterized, and the same time without distorted meshes at the place of the sand body pinches out.

The sedimentary time unit model obtained by this technology is used for modeling of subsequent facies and property. The results show that the results from the facies model and property model are not different from those from the conventional method. The technology does not affect the results from the facies model and property model, showing that the technology has good practicability.

5. Conclusion

(1) Shallow lacustrine fluvial-dominated delta sedimentary system develops in the VII oil group of Gasikule N_2^1reservoir. The subfacies of the VII oil group are the delta front subfacies and belong to highly constructional delta deposit. The sand bodies develop mainly by means of progradation. The main type of sand body is the distributary sand bar sand body. The main sand body is the mouth bar sand body. According to the characteristics of the interbed, the mouth bar lobe complex can be further subdivided to give a single mouth bar lobe

(2) According to the method for division of the residual muddy intercalation period, one Level 1 single sand body was identified in the VII-15 member and composed of three lobe complexes, and Level 2 single sand body 14 was further identified. No.1 and No.2 lobe complexes were composed of four Level 2 single sand bodies, respectively, and No.3 lobe complex was composed of six Level 2 single sand bodies

(3) The "sandwich" layer point coincidence modeling technology is proposed to accurately describe the multiperiod sand bed sedimentary units, without the constraint of the accuracy of longitudinal mesh, distorted meshes at depositional termination, and impact on subsequent attribute modeling. The technology accurately describes the distribution

characteristics of the barrier layer and interbed, especially suitable for the studies with the requirements for high accuracy of the barrier layer and interbed distribution, such as gas flooding simulation of reservoirs, and provides a fine geological research basis for the study on oil and water movement law and remaining oil

(4) With the method proposed in this paper, we can well describe the multistage sand bodies in the process of sedimentation and also can depict the argillaceous intercalation between different sand bodies and characterize this geological knowledge through the three-dimensional geological model, which is very practical for the fine geological research of reservoir, and provides a new idea and means for reservoir sand body research

Data Availability

The data involved in this paper are all in the text of the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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