Control of the Cretaceous Paleofluid Potential on the Source-Distal Lithologic Reservoirs in the Western Tabei Area of the Tarim Basin

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1. Introduction

The oil and gas reservoirs discovered in the Paleogene and Cretaceous clastic rocks in the western Tabei area of the Tarim Basin are mainly located in the Yingmaili, Yangtake, Hongqi, and Yaha fault zones. These reservoirs are mainly structural oil and gas reservoirs, with good reservoir properties and presenting high daily production of wells. However, due to the small area and low closure of the traps, it is difficult to evaluate the structural oil and gas reservoirs during later exploration.
The successive discoveries of two Paleogene large-scale lithologic reservoirs in Yudong and Quele have demonstrated the great potential of the western Tabei area for forming large-scale lithologic/stratigraphic reservoirs. However, the exploration of Cretaceous lithologic reservoirs has not broken through, and further research is needed. For the specific geological conditions of the Cretaceous in the western part of Tabei, around the advantageous path and direction of distant source oil and gas migration, find favorable facies belts with developed lithology, and confirm the large-scale lithologic reservoirs of the Cretaceous, and the advantageous path and direction of oil and gas migration are the key factors.

In 1972, the concept of “oil system” was first proposed by Dow; many scholars have deeply discussed it, which has evolved into the concept of “petroleum system” [1–4], in which the migration path is an important basic element in the petroleum system. After more than half a century of development, fluid potential theory [5, 6], as a method of studying the migration path, has been continuously expanded and improved and has been widely used.

In the western part of the North Tabei, previous studies on the source and migration path of oil and gas in the Mesozoic and Cenozoic have clarified three understandings: (1) The oil and gas in the Mesozoic and Cenozoic strata come from the source rocks of the Triassic and Jurassic in the northern Kuqa Depression. (2) The key accumulation period of Triassic source rocks is the Kangcun period, and the key accumulation period of Jurassic source rocks is the Kuqa period. (3) The two sets of regional unconformities at the bottom of the Cretaceous and the Jurassic are the main paths for the lateral migration of oil and gas to the western part of the North Tabei.

Based on this basis in this paper, the oil sources of the well-drilled reservoirs in the Cretaceous and Paleogene in the western part of the North Tabei have been carefully compared in the horizontal and vertical directions, and the characteristics of plane zoning and the law of vertical stratification of oil and gas derived from two sets of hydrocarbon sources are sorted out. Combined with regional tectonic evolution, the main source and transportation path of oil and gas in the Cretaceous strata were determined. In view of the study area with a large area, the 2D seismic data mainly used, seismic acquisition with long time, and different processing methods for different target layers, the paleo-fluid potential of the Cretaceous during the critical accumulation period is obtained by using the combination of well-seismic research with the Hubbert formula. The two key parameters are obtained using logging data and seismic data, respectively, and the restored paleo-fluid potential results are used to verify the rationality of geochemical indicators and the distribution range of source rocks. The recovery results were analyzed, and the advantageous migration path and direction of oil and gas were determined, which provided a basis for the next step of oil and gas exploration.

2. Geological Background

The western Tabei area is located on the Tabei Uplift of the Tarim Basin, bordering the Quilitage structural belt and Yangxia depression in the north and the Awati and Manjiaer depressions in the south. This area presents itself as an elongated strip with narrow width along the north-south direction and extended length along the east-west direction” in plan view (Figure 1). The Cretaceous is the main oil-producing strata in this area. Due to Indosinian and Hercynian nappe thrusting, the paleostructure characterized by “high in the north and low in the south” was formed in the western Tabei area; then, during thrusting compression of the southern Tianshan in the Yanshanian-Himalayan period, the Kuqa Depression was formed in the northern part of the western Tabei area, resulting in the subsidence of the northern part of the Western Tabei area and forming an inverted monocline that is “low in the north and high in the south.” The Cretaceous is composed of delta and shore-shallow lake facies, and the provenance is mainly attributed to the south. The delta front of the Cretaceous system and the beach and bar deposits of shore-shallow lake facies are all high-quality reservoirs with high porosity (12%–20%). Hydrocarbons of the Cretaceous reservoirs discovered in the western Tabei area mainly come from the Jurassic and Triassic continental source rocks in the Kuqa Depression of the northern part of the Western Tabei area [7, 8], and hence, the Cretaceous reservoirs are classified as source-distal reservoirs [8–11].

3. Analysis of Hydrocarbon Migration Paths

3.1. Determination of the Key Accumulation Period. Studies have shown that the continental oil resources can be divided into two categories, oil of coal-beariong formation series and lacustrine oil, and they are attributed to two periods of hydrocarbon accumulation. The lacustrine oil is mainly derived from the Triassic, and its accumulation period is 10–8 Ma for deposition of the Kangcun Formation. The oil of oil-bearing series is mainly derived from the Jurassic, and its corresponding accumulation period is 3–2 Ma for deposition of the Kuqa Formation. Previous studies focused on the sources of oil and gas, the types of source rocks, and the potential for hydrocarbon generation, and yet, no sufficiently in-depth research on the preferential paths, directions, oil and gas adjustment, and preservation for source-distal oil and gas migration has been found [12].

3.2. Determination of Migration Paths. Previous research shows that the pathways for oil and gas in the western Tabei area are “step-fault type” [13]. That is, oil and gas first migrate along the regional unconformities at the bases of Paleogene and Cretaceous to the western Tabei area, and then move along the normal fault vertical pathway of late Yanshanian into traps, and finally accumulate to form hydrocarbon reservoirs. However, the specific migration path of oil and gas generated from the Jurassic and Triassic source rocks is not yet identified.

Analysis of the tectonic evolution of the unconformities at the bases of the Paleogene and Cretaceous shows that from early deposition of the Neogene Kangcun Formation to the end of deposition of the Kuqa Formation, the northern Quilitage structural zone, located in the western Tabei
area, had not been uplifted, and oil and gas from Jurassic
and Triassic source rocks in the Kuqa Depression had unim-
peded migration channels from north to south. Thus, hydro-
carbons can migrate smoothly along the unconformities to
the western Tabei area. By the end of deposition of the Kuqa
formation, the Qiulitage structural zone began to come into
being and finalized, during which Jurassic source rocks
entered the main gas generation phase, and yet, Triassic
source rocks had passed peak hydrocarbon generation. This
affected the lateral migration of oil and gas from Jurassic
source rocks to the western Tabei area.

The distribution of oil and gas from Jurassic and Triassic
source rocks in Kuqa Depression is characterized by vertical
stratification and horizontal zonation. Vertically, oil and gas
accumulated in Cretaceous interior (k1hp, k1bs), including
those discovered from the upper and lower strata of Creta-
ceous bottom unconformity, are all dominated by lacustrine
oil derived from Triassic source rocks. There are Jurassic/ Triassic mixed source oil and gas in the strata above and
below the Paleogene bottom unconformity (Figure 2). First
of all, tricyclic terpanes reflect the formation conditions of
oil and gas and the source of parent materials. In Table 1,
the ratio of C19 tricyclic terpanes to C21 tricyclic terpanes
and the ratio of C19 tricyclic terpanes to C23 tricyclic ter-
panes of well M7 and well M12 in Paleogene is higher than
those in Cretaceous. That is because the oil and gas of Paleog-
ene came from Jurassic coal measure source rocks, and the
parent rocks of coal measure strata are mainly humic type III
kerogen. Compared with the parent rock of lacustrine mud-
stone, this type has higher C19 tricyclic terpane and lower
C21 tricyclic terpane and C23 tricyclic terpane values. It
indicates that the oil and gas sources in the Cretaceous inte-
rior strata are different from those in the unconformity sur-
face at the bottom of Paleogene, and the oil and gas in the
Cretaceous are from the Triassic lacustrine source rock in
Kuqa Depression, whereas the oil and gas at the unconfor-
mity surface of Paleogene bottom are derived from Jurassic
cal measure source rocks. In addition, the methylidiben-
zothiophene contents in aromatic hydrocarbons of different
wells in Table 1 are quite different, which also proves that
the parent rock formation conditions of discovered oil and
gas in Paleogene and Cretaceous are different.

In the plane, the origin of the oil and gas gradually
changes from west to east (Yudong–Yangtuck–Yingmaili–
Hongqi–Yaha), from Jurassic coal-bearing source rocks to
Jurassic and Triassic source rocks to mixed source oil and
gas (Figure 3). It can be seen from Figure 4 that the ratios
of C30 rearranged hopane/C30 hopane and C27 rearranged
sterane/C27 sterane are both high in Yudong and Yangtak
areas. The ratios of C30 rearranged hopane/C30 hopane
are between 0.4 and 0.8, the ratios of C27 rearranged
hopane/C27 sterane are between 0.8 and 1.4, and the ratio
range from 0.2 to 1 are high abundance rearranged hopane.
The ratios of C30 rearranged hopane/C30 hopane and C27
rearranged sterane/C27 sterane in Yingmaili are 0.2-0.4
and 0.2-0.6, respectively. Although the above ratios belong
to high abundance rearranged hopane, the ratios of C27
rearranged hopane/C27 sterane in Yingmaili are close to
low abundance rearranged hopane, which are obviously dif-
ferent from those in eastern Yudong and Yangtak. The rela-
tionship between rearranged hopane compounds in crude
oil samples shows that rearranged hopane compounds with
similar carbon skeleton structure have relatively good corre-
lation, while rearranged hopane compounds with different
carbon skeletons have a different correlation with the for-
mer. Therefore, the carbon skeleton structure of crude oil
in eastern Yudong and Yangtak areas is different from that
in the central Yingmaili area.

The tectonic evolution and the horizontal distribution
characteristics of oil and gas have confirmed the vertical
and horizontal distribution features of oil and gas—specifi-
cally, during deposition of the Neogene Kangcun Formation,
the Triassic lacustrine source rocks were in peak hydrocar-
bon generation, and oil and gas mainly migrated along the
unconformities at the Cretaceous base to the western Tabei
area and accumulated in high-quality reservoirs and traps;
in addition, oil and gas also migrated upward along the Late
Yanshanian faults to the Paleogene and accumulated in
high-quality reservoirs and traps. Subsequently, by the time
for deposition of the Kuqa Formation, the Triassic lacustrine
source rocks had passed its peak of hydrocarbon generation,
and yet, the Jurassic coal-series source rocks were just in its
peak hydrocarbon generation; oil and gas migrated along the
unconformities at the base of Paleogene to the southern

Figure 1: Structural location of the western Tabei area in the Tarim Basin.
**Figure 2:** Vertical distribution of Jurassic and Triassic oil and gas in the western Tabei area.

**Table 1:** Geochemical analysis of Paleogene and Cretaceous reservoirs in well M7.

| Well no. | Stratigraphy | C19 tricyclic terpane/C21 tricyclic terpane | C19 tricyclic terpane/C23 tricyclic terpane | γ cerotane/ C30 hopanoid | C30 diahopanes/ hopanoid | C27 rearranged sterane/C27 sterane | Content of methyldibenzothiophene in aromatic hydrocarbons (%) | δ 13C (%) |
|----------|--------------|---------------------------------------------|---------------------------------------------|--------------------------|--------------------------|--------------------------------|--------------------------------------------------|-----------|
| M12      | E            | 0.653                                       | 0.801                                       | 0.157                    | 0.231                    | 0.776                          | 0.51677                                          | -29.9     |
| M7       | E            | 0.464                                       | 0.511                                       | 0.389                    | 0.301                    | 0.495                          | 0.46611                                          | -29.5     |
| M12      | K            | 0.253                                       | 0.242                                       | 0.291                    | 0.198                    | 0.493                          | 0.47909                                          | -31.2     |
| M7       | K            | 0.252                                       | 0.228                                       | 0.281                    | 0.217                    | 0.339                          | 0.48321                                          | -30.6     |
| M7       | O            | 0.391                                       | 0.323                                       | 0.267                    | 0.204                    | 0.322                          | 0.50584                                          | -30.1     |

**Figure 3:** Horizontal distribution of Jurassic and Triassic oil and gas in the western Tabei area.
slope for accumulation and, in the same time, moved vertically along the faults to the strata below the upper Paleogene gypsum layer. From what has been discussed above, it can be concluded that hydrocarbons from the Triassic lacustrine source rocks migrated along the Cretaceous basal unconformities and Late Yanshanian faults during deposition of the Neogene Kangcun Formation. As for hydrocarbon from Jurassic coal-series source rocks, they migrated along the Paleogene basal unconformities and Late Yanshanian faults during deposition of the Kuqa Formation.

Therefore, based on the above two research results, it is determined that the hydrocarbons from the Triassic lacustrine source rocks in Kuqa Depression migrated to the Cretaceous in the western Tabei area along the Cretaceous bottom unconformities and late Yanshanian faults in the key accumulation stage of the Neogene Kangcun period.

4. Restoration of Paleofluid Potential

4.1. Selection of Methods. The secondary migration of oil and gas follows the basic law of fluid movement. Nowadays, the research on secondary migration of oil and gas is mainly carried out by four types of methods, namely, geochemical methods, physical and geophysical methods, experimental simulation, and numerical simulation [14–16].

It is necessary to identify the preferential migration path and direction of hydrocarbons, as the differentiated migration paths of Triassic source rocks have been demonstrated. According to Hubbert’s equation [17], the mechanical energy of fluids per unit mass is defined as the fluid potential, which is composed of three mechanical energies: potential energy, unit mass pressure energy, and kinetic energy. When the fluid flow speed is slow, the kinetic energy can be ignored. According to its definition, the fluid potential proposed by Hubbert ignores the capillary pressure that is common in strata. In England’s theory [18], the fluid potential is the work that must be done to transfer a unit volume of fluids from the reference point to the target point, which has an extra term for capillary pressures, compared with Hubbert’s definition of fluid potential. In the case of the flow, velocity is slow, and the capillary pressure has negligible influence on the fluid potential, and the definitions are basically equivalent. The western Tabei area is a secondary structural unit covering 15000 km$^2$. It has been found that the furthest distance between the reservoir and the hydrocarbon generation center is up to 130 km. Given this, it can be presumed that the underground fluid flows very slowly, and accordingly, the capillary pressure can be ignored. So, Hubbert’s equation can be used to calculate the fluid potential of hydrocarbons from the Triassic during the key accumulation period. Migration of fluids through strata is controlled by the fluid potential distribution across the underground environment. Fluids always flow from the high-potential area to the low-potential area. Different fluids move in accordance with the corresponding distribution of their own potential fields, which can be simplified and expressed as

$$Q = gz + \frac{1}{\rho} \int_0^p dp,$$

Figure 4: Crossplot of ratios of C30 rearranged hopane/C30 hopane and C27 rearranged sterane/C27 sterane.
reasonable forecast of interval velocity, which is now mainly based on seismic and well logging data. The 2D seismic data processing in the study area is troubled by expanded gaps among times the work is done, and the results are seen with apparent closure error and differences of energy and processing methods. Moreover, the 3D seismic data are characterized by its high amplitude preservation and low resolution, and the original target for processing is the Ordovician carbonate rocks presenting themselves as a bead string in reflection, which have great impacts on the data of shallow strata. Therefore, it is difficult to obtain a universal average interval velocity from seismic data. However, drilling activities have covered the whole area, and acoustic logging has been performed in all these wells, so the acoustic logging data can be normalized to further calculate the interval velocity. The specific research flow of paleocurrent potential in this area is shown in Figure 5.

4.2. Paleoburial Depth during Key Accumulation Periods. From Cretaceous to the Neogene deposition of the Kuqa Formation in the western Tabei area, the tectonic activity of Yanshanian is relatively weak, and there is no obvious denudation among strata. There are mainly three unconformity surfaces, namely, unconformities between Neogene and Paleogene, Paleogene and Cretaceous, and Cretaceous and Paleozoic (Figure 6). The Neogene/Paleogene unconformity is angular unconformity, and the scale of denudation is very small, which can be basically ignored. The Paleogene/Cretaceous unconformity is also angular unconformity, and denudation occurs locally. In order to restore the paleostructure during hydrocarbon accumulation, time-depth conversion must be performed.

In view of the local erosion unconformity in the high part of the Paleogene/Cretaceous, the sequence ratio method combining well logging and seismic [19] was used to restore the paleostructure of the Cretaceous base during deposition of the Kangcun Formation. Based on the acoustic logs of wells, the eroded thickness was restored, and the whole region interpolation was carried out using eroded thickness of strata of single wells. Then, the thickness between the bases of the Neogene Kangcun Formation and Cretaceous bottom was calculated, and the paleostructure was corrected in the seismic profile. The restoration results have shown that during deposition of the Kangcun Formation, there was an uplift along the NE direction present in the Cretaceous paleostructure, which gradually decreased to the northwest and southeast to form slopes (Figure 7).

4.3. Calculation of Paleopressures during Key Accumulation Periods. In order to obtain the formation pressure, extensive attempts have been made, such as the equivalent depth method [20], bulk modulus method, and Young’s modulus method [21]. Filippone [22] is the first one to directly calculate the formation pressures from interval velocity, on the basis of drilling and well logging data such as density, porosity, and pressures of underground rocks. The equation is as follows:

\[ p_f = p_{ov} \frac{v_{max} - v_i}{v_{max} - v_{min}}, \]  

(2)

where \( p_f \) is formation pressure, \( p_{ov} \) is the overburn pressure, \( v_{max} \) is the velocity of the rock framework, \( v_{min} \) is the pore fluid velocity, and \( v_i \) is the average interval velocity. When the porosity of the formation is 0, \( p_f = 0 \); when the porosity of the formation is 100%, \( p_f = p_{ov} \). Equation (2) has achieved good performance in the prediction of formation pressures in petroliferous basins. It can be seen from Equation (2) that as long as \( p_{ov} \) and \( v_i \) are available, \( p_f \) can be calculated. Therefore, the key is to get \( v_i \).

The average interval velocity \( v_i \) of the Cretaceous during the accumulation period is calculated using the Wyllie time-average equation:

\[ \frac{1}{v_{int}} = \frac{1 - \Phi}{v_{max}} + \frac{\Phi}{v_f}, \]  

(3)

According to \( v_{max} \), the pore fluid velocity \( v_f \), and \( \Phi, v_i \) of the Paleogene and Cretaceous during the accumulation period can be calculated. \( \Phi \) is unknown, and Zhen et al. [23] believe that \( \Phi \) follows a binary function of burial depth \( h \) and burial time \( t \), namely,

\[ \ln \Phi(h, t) = Ah + Bt + Cht + \Phi_0, \]  

(4)

where \( \Phi_0 \) is the initial porosity and \( A, B, \) and \( C \) are constants.

By reconstructing the burial history of the study area, the burial depth of the Cretaceous during the key accumulation period was determined (Figure 8). The porosity of the present Cretaceous formation is calculated using the acoustic travel time difference logs of 45 wells, and the porosity of the formation at the surface depth, namely, \( \Phi_0 \), is obtained from the crossplot of porosity and depth (Figure 9). On the basis of \( \Phi_0 \), burial history, and current porosity data, Equation (5) depicting variation of \( \Phi \) with \( t \) and \( h \) is obtained using the least square fitting method:

\[ \ln \Phi(h, t) = 1.434t - 0.01h - 0.000244ht + 51.4. \]  

(5)

Then, according to \( \Phi \) and Equation (3), \( v_i \) of the Cretaceous during the key accumulation period is obtained.

4.4. Calculation of the Overburden Pressure during the Key Accumulation Period. Using the density-depth crossplot (Figure 10), Zhen et al. [21] managed to restore the density \( \rho \) of strata of different ages, and the relationship is as follows:

\[ p_{ov} = \int_0^H \rho(h)gdh. \]  

(6)

Therefore, the overburn pressure \( p_{ov} \) for the Cretaceous during the key accumulation period can be obtained using
a well density curve, density-depth crossplot, and Equation (6).

4.5. Paleopressures during the Key Accumulation Period. Following the above procedure, the two key parameters $p_{ov}$ and $v_i$ in Equation (2) can be obtained so as to calculate the Cretaceous paleopressure in the study area during the key accumulation period (Figure 11). The results show that the paleopressure gradually decreased from north to south during the key accumulation period, and the Kuqa Depression in the north was a hydrocarbon kitchen, which is consistent with the characteristics that the pressure decreases gradually during hydrocarbon migration from the hydrocarbon generation center to the areas far away from the source rock.

4.6. Validating Restoration of the Paleo Fluid Potential Field. Via Equation (1), the paleofluid potential of the Triassic lacustrine source rocks during the key accumulation period is restored, and the preferential migration direction and path of hydrocarbons to the western Tabei area are determined (Figure 12). The results show the following: (1) The paleofluid potential field of the Cretaceous during the key accumulation period is characterized by “high in the north and low in the south,” which is consistent with the gradual decrease of fluid potential along the migration distance from the northern hydrocarbon generation center (Kuqa Depression) to the western Tabei area. (2) During deposition of the Kangcun Formation, the Cretaceous fluid potential field migrated as a whole from northeast to southwest along four preferential paths, namely, the q6-t6-k1 well-tie direction in the Quele and Yudong areas; two paths in the Yingmaili area, one in the west along the t2-M8-M14 well-tie direction, and the other in the east along the M21-M7-M18 and M24-M5-M1 well-tie direction; and the h23-h22-h27 well-tie direction in the Yaha area. The main flow direction coincides with the fact that the Triassic lacustrine source rocks are mainly distributed in the northeast of the Kuqa Depression. (3) In addition, the nitrogen isotope ratio is an important geochemical indicator of hydrocarbon migration paths. Through analysis of nitrogen isotope indicators, it is found that the nitrogen isotope ratio decreases from 1.03 $\mu g/g$ (well M7) to 0.7 $\mu g/g$ (well M15) and from 0.5 $\mu g/g$ (well M16) to 0.09 $\mu g/g$ (well M14) along the preferential migration paths of the NE-SW preferential migration paths of the Cretaceous basal fluid potential during deposition of the Kangcun Formation. Oil and gas show data demonstrate that the nitrogen-containing compound indicator is also characterized by decline along the preferential migration path of the paleofluid potential, which confirms the migration direction of the paleofluid potential. In conclusion, the paleofluid potential of the Cretaceous during the key accumulation period reasonably reflects the preferential migration path and direction of Triassic-sourced oil and gas in the western Tabei area, and areas on the migration path and direction of the paleofluid potential field during the accumulation.
Figure 6: Stratigraphic characteristics of the Cretaceous-Neogene Kuqa Formation.

Figure 7: Cretaceous paleostructure before deposition of the Kangcun Formation in the western Tabei area.
period are the main favorable areas for source-distal hydrocarbon charging.

5. Discussion

5.1. Migration, Adjustment, and Preservation of Source-Distal Hydrocarbons. According to the planar structure evolution of the Cretaceous base in the western Tabei area and the restored paleofluid potential field, the evolution process of source-distal hydrocarbon migration, adjustment, and preservation of Cretaceous reservoirs is clarified, and the favorable area of source-distal oil and gas migration and accumulation in the western Tabei area is further demarcated.

The tectonic evolution map of the Cretaceous base shows that the paleogeomorphology before Cretaceous deposition was a slope that is high in north and low in south (Figure 13). Due to the orogeny of the Southern Tianshan Mountain in the north, the western Tabei area was subjected to subsidence of its northern part. During the Neogene Kangcun period, a paleobeam structure was formed in the Yudong-Yingmaili-Donghetang-Yaha area (Figure 7). In the Neogene Kuqa period, the northern part of this area continued to subside and the southern slope was uplifted, while the paleobeam structure of the Yudong-Yingmaili-Donghetang-Yaha area remained, yet with a reduced area. Meanwhile, nose-like uplifts in the north of the Yingmaili and Yudong area were initially formed (Figure 14). To the present day, the western Tabei area presents a slope shape that is high in the south and low in the north. The paleobeam structure of the Yudong-Yingmaili-Donghetang-Yaha area has disappeared, but the major Yudong and Yingmaili nose-like uplifts have been formed, which inherit the geometries of the paleobeam structures (Figure 15).

Formation of the Cretaceous reservoirs occurs during the Neogene Kangcun period, and the accumulation period was relatively late. During that time, a large amount of oil and gas migrated along the unconformity at the bottom of the Cretaceous to the western Tabei area from the four preferential oil and gas pathway directions of the paleofluid
potential field. Accordingly, the paleobeam structure on the main migration path of oil and gas was highly likely to be charged by hydrocarbons, and source-distal hydrocarbons accumulated in the paleobeam structure of the Yudong-Yingmaili-Yaha area. In the Neogene Kuqa period, the range of the paleobeam structure was reduced, and the oil and gas that accumulated on the periphery of the paleobeam structure were subjected to loss and adjustment. Nonetheless, the early oil and gas were still preserved in the initially formed nose-like uplifts in the Yudong and Yingmaili areas. At present, the paleobeam structure has disappeared, and the southern part of this area has been uplifted. The oil and gas preserved in the paleobeam structure have been adjusted to the south as a whole. However, the inherited nose-like uplifts in the Yudong and Yingmaili areas have well preserved the early oil and gas, which therefore makes it still an area with abundance of source-distal hydrocarbons and a favorable area for further exploration of lithologic oil and gas reservoirs.

Therefore, from the reservoir forming period to the present, the slope from Kuqa Depression in the north to the west of Tabei has been high in the south and low in the north. The oil and gas generated by source rocks in Kuqa Depression have been filled into the west of Tabei. Only in the process of evolution, the structure in the west of Tabei has been partially adjusted, and the formed reservoirs have been

Figure 11: Distribution of Cretaceous paleopressures during deposition of the Kangcun Formation in the western Tabei area.

Figure 12: Planar distribution of the Cretaceous paleofluid potential during deposition of the Kangcun Formation in the western Tabei area.
slightly adjusted, which has good preservation for the formed reservoirs as a whole (Figure 16).

5.2. Exploration of Source-Distal Lithologic Reservoirs. The main exploration targets in the Cretaceous are, from bottom to top, the Shushanhe Formation and the Baxigai Formation. The sedimentary facies are branched delta and shore-shallow lake facies, and the sedimentary model is retrogradational. The provenance during sedimentation is mainly attributed to the south, and the current structural pattern is also characterized by being high in the south and low in the north. Based on the analysis of the matching between the structural pattern and sedimentary model of the two Cretaceous stratigraphic layers, lithologic reservoir exploration should focus on the periphery of the Yudong-Yingmaili source-distal oil and gas enrichment area and look for discontinuous thin sand bodies in the outer front of the branched retrogradational delta or the sand bodies with lateral mudstone barriers in the flank of the branched delta (Figure 17).
Figure 15: The current structure of the base of Cretaceous in the western Tabei area.

Figure 16: Remote reservoir forming model under complex transport system.

Figure 17: Sand correlation profile of the Cretaceous Baxigai Formation in the Yingmaili area, the western Tabei area.
6. Conclusion

(1) By analyzing the source-distal migration path of oil and gas in the western Tabiei area of the Tarim Basin during the key accumulation period, it is clarified that the oil and gas of Cretaceous reservoirs are mainly from Triassic source rocks; the Neogene Kangcun period is the key accumulation period; hydrocarbons migrate to the western Tabiei area along the Cretaceous basal unconformities and Late Yanshanian faults. Given this, the paleofluid potential field can be restored to identify the source-distal preferential migration path and direction of oil and gas.

(2) According to the geological characteristics of the study area, the paleoburial depth was restored by the imression method and the sequence ratio method, and the paleopressure was calculated using the Fillipone formula. On the basis of the Hubbert theory, the paleofluid potential of the Triassic oil and gas during the key accumulation period was reasonably reconstructed, and then, four preferential migration paths and directions of source-distal oil and gas were determined, which was combined with the planar structural evolution of the base of Cretaceous to further confirm that the Yudong-Yingmaili area is a favorable area of source-distal hydrocarbon migration and accumulation to Cretaceous strata.

(3) In terms of the favorable areas for source-distal oil and gas migration and accumulation to Cretaceous strata, the forward distal end and lateral flanks of the branched retrogradational delta are the favorable facies belts for the next exploration of lithologic oil and gas resources. The recent breakthroughs in the lithologic reservoirs of wells D7 and M46 have confirmed that the findings of this research on the preferential source-distal migration paths and accumulation positions of hydrocarbons are of great guiding values for exploration deployment of Cretaceous lithologic reservoirs far away from source rocks.

Data Availability

All raw data are in the article chart. The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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