Analysis of major controlling geological factors on coalbed methane enrichment and accumulation model of low coal rank in Tuha-Santanghu Basin

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Abstract. The low-rank coalbed methane resources in the Tuha-Santanghu Basin are rich, but the degree of exploration is low. The main controlling factors and accumulation model of coalbed methane accumulation are insufficiently understood, which restricts the exploration and development practice. In order to find out the main controlling factors and accumulation mode of low rank coalbed methane in Tuha-Santanghu Basin, from the aspects of low coal rank coal seam distribution, coalbed methane gas types and origins, comprehensive considerations such as hydrogeology, tectonic and sedimentary conditions, etc, the reservoir-forming conditions of low rank coalbed methane gas are analyzed, and the accumulation model is proposed to further explore direction. The results show that hydrogeological condition affect the generation and enrichment of low rank coalbed methane in this area, which is an important condition for the formation of low rank coalbed methane. It is advantageous to save the low-rank coalbed methane with weak runoff. Different tectonic conditions have different effects on the preservation of coalbed methane, which can be divided into favorable preservation and destructive preservation. The influence of coal-forming environment on coal's gas-generating potential, top and bottom lithology and coal reservoir physical has a important impact on low rank coalbed methane. The comprehensive study proposes two types of low-rank coalbed methane accumulation models in the Tuha-Santanghu Basin: gas accumulation model of basin margin slope zone and gas accumulation model of stagnant confined water + lithologic plugging coalbed methane in small fault sag. Comprehensive analysis shows that coal-bearing slope zone of basin margin with favorable hydrogeological conditions and coalbed methane reservoir with good preservation conditions in small fault sag with retaining confined water+lithologic plugging characteristics will be the key exploration area in the future.

1. Introduction
Low rank coal generally refers to coal with vitrinite reflection ($R_o$) less than 0.65%[1]. Low-rank coalbed methane is widely distributed in China. The main basins containing lower and middle Jurassic coalbed are Tuha, Santanghu, Junggar, Ordos and Chaoshui etc basins, which contain abundant coalbed methane resources. The fourth evaluation of oil and gas resources shows that low-rank coalbed methane accounts for 35% of the total coalbed methane resources in China, but the current level of exploration and development is relatively low[2]. The successful practice of the development of coalbed methane in the Powder River Basin of the United States, the Surat Basin of Australia, and Albert of Canada proves that the low coal rank coal seam has the advantages of large total coal seam thickness, high resource abundance, and no need for fracturing, and have great potential for development. At present, the
exploration of coalbed methane in China is mainly concentrated in the middle and high rank coalbed methane areas. The exploration and development of low rank coalbed methane are carried out only in a few blocks, such as Turpan-Hami Basin, Santanghu Basin, Fuxin Basin, Junggar Basin and Erlian Basin. Previous studies have carried out some research on the accumulation conditions and accumulation model of low-rank coalbed methane in some blocks, but the low-rank coal-bearing basins in China have complex structures, and the coalbed geological conditions and resource distribution in different basins are relatively uneven. China still lacks relevant research on the lack of gas control factors in low-rank coal seams, insufficient understanding of hydrocarbon accumulation conditions and accumulation model, and no significant progress has been made in the selection of exploration and development target areas. Based on the analysis of the genesis of low-rank coalbed methane in Tuha-Santanghu area, this paper discusses the important conditions for the formation of low-rank coalbed methane reservoirs in the study area from the aspects of hydrogeology, structure and sedimentation, puts forward the reservoir-forming model in this area, and clarifies the exploration direction of low-rank coalbed methane, which has a certain reference for the follow-up exploration and development of coalbed methane in the study area.

2. Regional Geological
The Tuha Basin is surrounded by mountains and hills (Fig 1). Geomorphologically, it is a narrow and long intermountain basin in the Tianshan Mountains, which near nearly east-west. The main structural line is east-west, and the north is deep and the south is shallow. The northern margin of the basin is the Bogeda Mountains, and the southern margin is the Jurotag Mountains. Coal seams in Turpan-Hami Basin are mainly developed in Badaowan Formation and Xishanyao Formation of Middle and Lower Jurassic [3-4]. The number of coal-bearing seams is generally 10-30, the cumulative thickness of coal seams is 30-80 m in most areas, and the thickest part is more than 200 m. Coal seams are widely distributed, and the coal-bearing area in the basin is $2.15 \times 10^4$ km$^2$.

![Fig 1. Regional map of Tuha-Santanghu Basin.](image)

Santanghu Basin is an intermountain basin between the two mountains, which is adjacent to the northern Tianshan Mountains in the South and Altai Mountains in the north (Fig 1). The two subsidence centers of the basin are located in Tiaohu sag and Malang sag. Coalbed methane exploration in Santanghu Basin mainly focuses on the coal seams of Xishanyao and Badaowan Formations of Middle and Lower Jurassic [3-4]. The number of coal seams is generally 2-15 seams. The cumulative thickness
of coal seams is 3 m to 70 m in most areas, and the thickness of single seam is 2 m to 60.6 m. Coal seams are widely distributed in the basin with an area of 6350 km$^2$. The coal in the two basins are dominated by low coal ranks, and the buried depth is generally <1200 m.

3. Low coal rank coalbed methane origins

The genesis of coalbed methane mainly includes biological origins, thermal origins, migration heat origins and mixed origins. Due to the shallow depth and low degree of evolution, the low-rank coalbed methane gas usually contains low thermogenic gas [5-6].

According to Seidle's research, low-rank coal mainly produces CO$_2$ gas, and almost no CH$_4$ gas and N$_2$ gas are generated. Domestic and foreign scholars generally attribute the cause of coalbed methane in low-rank coal to biogenetic gas [7-8]. Biogas can be further subdivided into primary biogas and secondary biogas. The primary biogas is formed in the early diagenetic stage, the burial is shallow, the pores are almost occupied by water, the coal adsorption amount is low, and at the same time, there is no effective upper cover capping, the generated gas is easy to escape, and it was difficult to preserve in the coal seam, resulting in a low overall gas content.

The generation of secondary biogenic gas has obvious characteristics of late transformation, such as stratum uplift, surface water supply, methane bacteria carrying other organic matter into methane, and continuous production of secondary biogenic gas under suitable burial depth, structure, hydrogeology and preservation conditions. The contribution of primary biogas to low rank coalbed methane is relatively low, and the supply of secondary biogas will greatly increase the content of coalbed methane, which is of great significance for the formation of low rank coalbed methane reservoirs.

The boundary between biogenetic gas and thermogenic gas is defined by $\delta^{13}$C$_1$ of -55‰ and $R_o$ of 0.65%. The $\delta^{13}$C$_1$ of the coal seam in the Shaerhu sag of the Tuha Basin is -61‰~58.4‰, and $R_o$ is less than 0.65%, which is characterized by biogas. The $\delta^{13}$C$_1$ of the coal seam in Hami depression is -62.97‰~63.69‰; the $\delta^{13}$C$_1$ of Dananhu sag is -71.7‰~66.5‰, all showing biogas characteristics.

Although $R_o$ of coal seam in Santanghu Basin is less than 0.65%, but the $\delta^{13}$C$_1$ is -53.05‰~52.63‰. Coal seam may be supplied with some thermogenic gas. The thermogenic gas contained in the coal seam may come from some coal seams with larger burial depth and higher evolution degree (Table 1).

Table 1. Statistical table of typical low coal rank blocks at home and abroad [10-11].

| Basin/Depression       | Age | Formation       | Buried depth (m) | $R_o$ (%) | Gas content (m$^3$/t) | $\delta^{13}$C$_1$ (%) | Gas source       |
|------------------------|-----|-----------------|------------------|-----------|----------------------|------------------------|------------------|
| Shaerhu sag            | J   | Xishanyao       | 400~1050         | 0.31~0.45 | 0.5~2.2              | -61~58.4               | Biogas           |
| Dananhu sag            | J   | Xishanyao       | 219~836          | <0.4      | <0.5                 | -71.7~66.5             | Biogas           |
| Hami depression        | J   | Xishanyao       | 900~1500         | 0.5~0.7   | 0.3~5.42             | -62.97~63.69           | Biogas           |
| Aidinghu sag           | J   | Xishanyao       | 487~1088         | 0.3~0.47  | <0.1                 | /                      | Biogas           |
| Santanhu Basin         | J   | Xishanyao       | <1100            | 0.39~0.55 | 3~7                  | -53.05~52.63           | Biogas, Thermogenic |
| Chaoshui Basin         | J   | Qingtujing      | 560~1200         | 0.39~0.71 | <0.4                 | -71.0~43.0; most are less than -55 | Biogas |
| Powder River Basin     | E   | Union           | 90~457           | 0.31~0.49 | 0~2.5                | -60.0~56.7             | Biogas           |
| Surat Basin            | J   | Wallon          | 0~850/281.06     | 0.4~0.6   | 2~10                 | -64.1~44.5             | Biogas, Thermogenic |
Fig 2. Identification of low-rank coalbed methane origins in the Shaerhu sag, based on \( \text{CH}_4/(\text{C}_2\text{H}_6+\text{C}_3\text{H}_8)\)-\(\delta^{13}\text{C}_{\text{CH}_4}\) (template from Kotarba [9]).

4. Gas-bearing characteristics of low-rank coalbed methane in Tuha-Santanghu Basin

The gas content of the Santanghu Basin is between 3 m\(^3\)/t and 7 m\(^3\)/t. The gas content in different sags of Tuha basin is quite different. The gas content in Shaerhu sag, Hami sag, Sandaoling area and Tuokexun sag ranges from 0.3 m\(^3\)/t to 5.42 m\(^3\)/t, while that in Aidinghu sag and Dananhu sag is less than 0.6 m\(^3\)/t and that in methane is almost zero.

According to the collected data of the Langmuir volume, the Langmuir pressure and the gas content of the individual blocks in the Tuha-Santanghu Basin. The strata pressure is estimated by 0.85 MPa/100, the theoretical gas content in this area is calculated, and the gas saturation is calculated by the gas content/theoretical gas content. The average gas saturation of the Santanghu Basin is 78.12%, and the gas saturation of individual samples is greater than 100%. The overall gas saturation is high, which is conducive to the later production of coalbed methane. The average gas saturation of the Shaerhu sag is 50.31%, and the overall gas saturation is not high, which is not conducive to the later production of coalbed methane.

Table 2. Estimation tables of gas saturation in individual blocks of Tuha-Santanghu Basin.

| Basin/Depression | Buried depth /m | Reservoir pressure /Mpa | Langmuir volume /m\(^3\) | Langmuir pressure /Mpa | Gas content /m\(^3\)/t | Theoretical gas content /m\(^3\)/t | Gas saturation /% |
|-----------------|----------------|-------------------------|--------------------------|------------------------|------------------------|-----------------------------------|------------------|
| Santanghu Basin | 843.87-1031.28 | 7.17-8.77               | 4.73-13.9                | 1.80-9.55              | 3.09-6.35              | 3.91-5.97                         | 55.78-138.86     |
| Average value   |                |                         |                          |                        |                        |                                   | 78.12            |
| Shaerhu sag     | 490.09-910.31  | 4.17-7.74               | 3.15-8.59                | 1.14-16.7              | 0.48-1.75              | 1.61-4.01                         | 22.94-80.49      |
| Average value   |                |                         |                          |                        |                        |                                   | 50.31            |

5. Geological conditions for enrichment of low rank coalbed methane

5.1. Hydrogeological conditions for enrichment of low rank coalbed methane
Low-rank coalbed methane is mainly biogas. Therefore, the hydrogeological conditions under which methane-carrying bacteria infiltrate into coal seams in present or historical freshwater are the important conditions for the generation of biogas in low-rank coalbed methane. Hydrogeological conditions have a great influence on the formation of low rank coalbed methane, mainly in the generation, migration and enrichment of low rank coalbed methane. The hydrological environment of weak runoff is beneficial to the enrichment of low rank coalbed methane. When the climate is dry and the stratum water is lacking,
the groundwater level is deep. There is no pressurized water in the shallow coal seam. The coalbed methane cannot be effectively adsorbed on the surface of the coal matrix, resulting in almost no gas content in the coal seam above the groundwater level.

The coal measures strata in the northern part of Santanghu Basin are uplifted, and the coal measures strata in Xishanyao Formation are buried shallowly near the top of the slope. Surrounding piedmont water flows into coal measures strata from outcrop area to downdip direction, and water supply is sufficient. The low salinity of water in coal measures strata (Table 3) is beneficial to the generation of biogas and the formation of high gas content (Figure 3a). In the coal-bearing sag along the northern margin of the Tuha Basin, the stratum water mineralization is diluted due to the supply of the piedmont water such as Tianshan Mountain, which is conducive to the generation of biogas, and the coal-bearing stratum has a certain gas content (fig 3b).

The Dananhu sag and the Aidinghu sag in the Tuha Basin, the south is adjacent to the Gobi Desert., the surface water supply is insufficient, and the mineralization of the stratum water is high, which is not conducive to the generation of biogas (Fig3c,d). Previous biological experiments showed that anaerobic bacteria could be completely inhibited when SO\(_4^{2-}\) concentration reached 960 mg/L. Methanobacteria would die completely when total salinity was higher than 10 000 mg/L. The coal seam water salinity in the Dananhu sag of the Tuha Basin is as high as 10000 mg/L, and SO\(_4^{2-}\) is between 1090 mg/L and 2310 mg/L, which indicates that there is a lack of surface freshwater replenishment and lack of biogas generation conditions in the coal-bearing strata. The coalbed methane content is low. The Aidinghu sag in the Tuha Basin also has similar geological features.
Fig 3. Variation of gas content with depth in different blocks of Tuha-Santanghu Basin.

The Shaerhu sag in the Tuha Basin is located in the Gobi Desert in the southern part of the Tuha Basin. The hydrogeological conditions are the stagnant water environment, the salinity is higher (greater than 10000 mg/L), and the water type is CaCl$_2$, which is not conducive to biogas production, but still has a certain gas content. According to the author's analysis, the fresh water infiltration in the geological history of the Shaerhu sag formed biogas, and then it was preserved to form a certain gas content.

Table 3. Stratum water salinity table of Tuha-Santanghu Basin.

| Area/Sag   | Well name | Buried depth (m) | Layer | Water type | Mineralization of water (mg/L) |
|------------|-----------|------------------|-------|------------|--------------------------------|
| Malang sag | Ma 206    | 874-879          | J$_2$x| Na$_2$SO$_4$| 5657                           |
|            | Ma 214    | 1102-1108        | J$_2$x| NaHCO$_3$  | 3827                           |
|            | Ma 208    | 761-769          | J$_2$x| NaHCO$_3$  | 3880                           |
|            | Ma 209    | 490-509          | J$_2$x| NaHCO$_3$  | 4160                           |
|            | Ma 205    | 1014-1023        | J$_2$x| NaHCO$_3$  | 4778                           |
|            | Ma 202    | 1151-1154        | J$_2$x| NaHCO$_3$  | 3882                           |
| Xixiagou area | Xi 9-13 | 673-680          | J$_2$x| NaHCO$_3$  | 2398                           |
|            | Xi 9-11   | 708-714          | J$_2$x| NaHCO$_3$  | 2865                           |
| Dananhu sag | /        | 676-1094         | J$_1$-J$_2$| Na$_2$CO$_3$| about 10000                    |
| Shaerhu sag | Shashi 1 | 475              | J     | CaCl$_2$   | 12000-36000/29500              |
|            | Shashi 2  | 685              | J     | CaCl$_2$   | 28000-35000/31800              |
|            | Shashi 3  | 624              | J     | CaCl$_2$   | 33000-36000/34600              |
|            | Shashi 4  | 573              | J     | CaCl$_2$   | 31000-36277/34100              |

5.2. Structural conditions for enrichment of low rank coalbed methane

Different structural conditions have different preservation effects on coalbed methane, and the whole is divided into favorable preservation and destruction preservation. The southern margin of the Turpan depression in the Tuha Basin is in the gentle slope zone of the basin, which is strongly cut by high angle fractures. The water-conducting and gas-conducting properties of the fault structure are strong, which is
not conducive to the preservation of coalbed methane, which is unfavorable for coalbed methane accumulation and low overall gas content. The steep slope gas-controlling structure of basin margin also developed in the northern margin of Tuha basin. Deep and large faults developed on the outside of steep slope, and thrusting faults developed on nappe. The sedimentary environment and coal-forming environment in this area are relatively stable, so the thickness of coal seam formed is large. However, the coal structure is broken, resulting in unsatisfactory conditions for coalbed methane accumulation and limited coalbed methane accumulation. But the Hami sag is relatively intact, and the structural sealing environment is weakly extruded, which is conducive to coalbed methane accumulation.

Fig 4. Schematic diagram of a section from the south to the north of the Tuha Basin.

In addition, when syncline and anticline change due to tectonic action, the slope stratum is more conducive to the enrichment of low rank coalbed methane than the gentle slope. Especially when the anticline is formed, it constitutes a structural high point, and the generated gas migrates to it, forming a high saturated coalbed methane reservoir similar to the conventional oil and gas anticline trap. Low-rank coalbed methane reservoirs with this feature have been found in the Powder River Basin of the United States. The production of coalbed methane in the high-point area has exceeded 2 times of its in-situ resources [12], and the gas content and gas saturation are high. The main reason is the large supply of gas in deeper parts.

Fig 5. High point gas-bearing model diagram of small anticline structure.

5.3. Sedimentary conditions for enrichment of low rank coalbed methane
The coal-forming environment affects the gas potential of coal, the top and bottom lithology of coal, and the physical properties of coal.

The content of macerals is an important factor affecting the gas content of coal seams. The gas generation potential of different types of macerals of coal is different. Previous studies have shown that the exinite has the strongest gas production capacity and is mostly distributed in the delta rich in organic matter. The gas production capacity of the vitrinite was second, and the inertinite was the worst. In the adsorption capacity, there are also significant differences between different maceral. The vitrinite has the strongest adsorption capacity, the inertinite is the second, and the exinite is the lowest. Vitrinite
usually accounts for the majority of low rank coals in China, followed by inertinite, and exinite is low, generally less than 10%. Therefore, vitrinite plays an important role in the generation and enrichment of coalbed methane [13-14]. Because the exinite has the strongest gas generating capacity, the high content of exinite is more favorable for the enrichment of low rank coalbed methane to a certain extent. For example, in Surat Basin of Australia, the content of exinite is about 20%[11], so the basin shows higher gas content characteristics.

The preservation of coalbed methane requires good sealing conditions, and the top and bottom lithology and thickness of coal have a great influence on the preservation of coalbed methane. In particular, the top lithology of the coal and its thickness directly determine the sealing capacity of the gas reservoir, and good sealing lithology can greatly reduce the loss of the generated coalbed methane, thereby maintaining a high gas content. Taking Shaerhu sag as an example, the top and bottom lithology of the main coal seam is mainly mudstone, with a maximum thickness of 300 m[3]. Mudstone is of great thickness, poor porosity and permeability and good sealing property, which is beneficial to the preservation of CBM. Although the Shaerhu Sag is located in the arid Tuha Basin and the groundwater supply is insufficient, the gas generated in some historical periods can be successfully preserved to form a certain gas content (Fig6a), which is closely related to the formation of effective plugging between the thicker mudstone and the huge thick coal itself. The development of mudstone overlying coal also prevents the loss of groundwater. At present, the water production of drainage wells is relatively large (part of which is up to 30m³/d) (Fig 7), which also shows the effective capping of overlying mudstone. The Jirgalangtu Sag in Erlian Basin has similar top and bottom lithological characteristics as that of Shaerhu Sag. Although it is located in arid and water-deficient areas, it still has a certain gas content (Fig6b).

![Fig 6. The variation of gas content with depth in coal-bearing sags with better sealing capacity.](image)

The sedimentary environment also affects the types of coal maceral. Different macerals and their contents will affect the porosity and permeability of coal seams, and then control the enrichment of coalbed methane [15]. Low rank coal is mainly matrix porosity type, and fracture are basically undeveloped. The matrix porosity is mainly affected by inertinite in coal. The higher the content of fusinoid group, the larger the matrix porosity of coal.
6. Reservoir-forming characteristics and exploration direction of low-rank coalbed methane in Tuha-Santanghu Basin

6.1. Accumulation characteristics
Coalbed methane enrichment areas in Tuha-Santanghu basin are mostly located in the slope zone of the basin at the edge of the mountain range, that is to say, the low-rank coalbed methane reservoirs in this area mainly belong to the reservoir-forming model of the slope zone of the basin margin (Fig 8). Coal seams are mostly exposed or near the surface in basin margin slope gas accumulation model. In the strata with better permeability along the top and bottom of coal seam, formation water can better seep into the deep stratum, dilute the deep formation water, and provide favorable conditions for the survival of methanogens and the generation of biogas. Under hydrodynamic conditions, a closed coalbed methane reservoir is formed. Most successful low-rank blocks at home and abroad belong to this type of reservoir-forming model. For example, the favorable area of the Powder River Basin in the United States is also developed in a single-wing slope, which facilitates the communication between groundwater and surface water, and shows the formation of a large amount of biogas. The coal seams in the Surat Basin of Australia are buried deep in the east and deep in the west, with a buried depth ranging from 0 to 850 m. The shallow salinity of the Surat Basin is low (<1000 mg/L), indicating that the water supply is sufficient, which is beneficial to the formation of biogas. The deep stratum has a high degree of mineralization (greater than 10,000 mg/L) [11], and the water is retained. Although there is a slight supply of thermogenic gas, the gas content is still lower than that of the shallower stratum.

In addition, the Shaerhu Sag in Tuha Basin is located in the Gobi Desert in the south of Tuha Basin. Its hydrogeological conditions are independent and closed hydrogeological bodies with high salinity (more than 10,000 mg/L). It is obviously in a stagnant water environment, which is not conducive to the preservation of biogas, but it still has a certain gas content. According to the author's analysis, biogenic gas was generated in the geological history of Shaerhu sag, which was preserved and formed a certain
gas content under the stagnant flow environment and favorable lithological capping of the top and bottom of the basin (Fig 9). The daily water production of many wells in Shaerhu sag is relatively large (part of which is up to 30 m³/d). This is related to the huge thickness of the coal seam (up to 200m in some areas) and the development of overlying mudstone in the sag [3]. The dense overburden mudstone and the huge thick coal itself hinder the loss of formation water and form stable confined water, which is conducive to the preservation of early biogas generated in a certain historical period.

6.2. Direction of exploration
In conclusion, the formation of low-rank CBM reservoirs in Tuha-Santanghu Basin is influenced by the hydrogeology, tectonic conditions and sedimentary environment of coal. Hydrogeological conditions affect the generation, migration and enrichment of coalbed methane. Weak runoff hydrological environment is more conducive to the generation and enrichment of low rank coalbed methane. Different tectonic conditions have different effects on the preservation of coalbed methane, which can be divided into favorable preservation and destructive preservation. The influence of coal-forming environment on coal's gas-generating potential, top and bottom lithology and coal's physical properties has an important impact on low rank coalbed methane.

On the basis of comprehensive consideration of the hydrogeology, tectonic conditions and sedimentary environment of low-rank coal in the study area, the author combines the hydrocarbon accumulation characteristics of low-rank coalbed methane, and optimizes the exploration target area of low-rank coalbed methane. Coal-bearing slope zone of basin margin with favorable hydrogeological conditions and appropriate structure. That is, the Santanghu Basin on the margin of Tianshan Mountains and the coal-bearing sag on the north side of Tuha Basin will be an important exploration direction in the future. At the same time, coalbed methane reservoir with good preservation conditions in small fault sag with retaining confined water+lithologic plugging characteristics in the interior of Turpan-Hami Basin will also be the key exploration area in the future.

7. Conclusion
(1) Biogenic gas is the main CBM in Tuha-Santanghu Basin. The gas content in Santanghu Basin is between 3 and 7 m³/t. The gas content in different sags of Turpan-Hami basin is quite different. The gas content in Shaerhu sag, Hami depression, Sandaoling area and Tuoerxun sag ranges from 0.3 to 5.42 m³/t, while that in Aidinghu sag and Dananhu sag is less than 0.6 m³/t and that in methane is almost zero. The gas saturation of Santanghu basin is higher than that of Turpan-Hami basin, which is conducive to later exploitation.

(2) The formation of low-rank coalbed methane reservoirs in Tuha-Santanghu Basin is influenced by coal hydrogeology, tectonic conditions and sedimentary environment. Hydrogeological conditions affect the generation, migration and enrichment of coalbed methane. Weak runoff hydrological environment is more conducive to the formation and enrichment of low rank coalbed methane. Different tectonic conditions have different effects on the preservation of coalbed methane, which can be divided into favorable preservation and destructive preservation. The influence of coal-forming environment on
coal's gas-generating potential, top and bottom lithology and coal's physical properties has an important impact on low rank coalbed methane.

(3) The low rank coalbed methane in Tuha-Santanghu Basin is mainly the reservoir-forming model of basin margin slope zone and enrichment model of stagnant confined water + lithologic plugging coalbed methane in small fault sag. Coal-bearing slope zone of basin margin with favorable hydrogeological conditions and appropriate structure. That is, the Santanghu Basin on the margin of Tianshan Mountains and the coal-bearing sag on the north side of Tuha Basin will be an important exploration direction in the future. At the same time, coalbed methane reservoir with good preservation conditions in small fault sag with retaining confined water+lithologic plugging characteristics in the interior of Turpan-Hami Basin will also be the key exploration area in the future.

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