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Retraction

Retracted: Reservoir Forming Conditions and Enrichment Law of Tight Sandstone Gas in Upper Paleozoic in Ordos Basin

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] J. Zhang and C. Zhang, "Reservoir Forming Conditions and Enrichment Law of Tight Sandstone Gas in Upper Paleozoic in Ordos Basin," *Adsorption Science & Technology*, vol. 2022, Article ID 2584733, 8 pages, 2022.

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Research Article

Reservoir Forming Conditions and Enrichment Law of Tight Sandstone Gas in Upper Paleozoic in Ordos Basin

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With the popularization of natural gas and the requirement of environmental protection, the development and utilization of natural gas are particularly important. The status of natural gas in China's oil and gas exploration and development is constantly improving, and the country pays more and more attention to the exploitation and utilization of natural gas. The tight sandstone of Upper Paleozoic in Ordos Basin has the characteristics of low porosity, low permeability, and large area of concealed gas reservoirs. With the increasing demand for natural gas in China, systematic analysis and research on the geological conditions and enrichment law of large area gas reservoirs of tight sandstone of Upper Paleozoic in Ordos Basin to guide exploration and production also pose a great challenge to the current level of natural gas exploration and development in China. In order to solve this problem, this paper takes the Upper Paleozoic tight sandstone in Hangjinqi area in the north of Ordos Basin as the research object, summarizes the natural gas accumulation conditions of tight sandstone according to the geological characteristics of Ordos Basin, determines the main control factors of gas accumulation by superposition method in combination with the distribution characteristics of natural gas, simulates the dynamic process of gas accumulation, establishes the gas accumulation model, analyzes the conditions of gas accumulation and enrichment by statistical methods, summarizes the accumulation and enrichment rules of natural gas, and predicts the favorable exploration areas for natural gas. The results show that the relationship between hydrocarbon source rocks, traps, migration and transportation, and other reservoir-forming conditions and the distribution characteristics of natural gas is summarized, and the main controlling factors of reservoir-forming are determined by superposition method. We simulate the evolution process of faults, strata, oil, gas, and water flows in the study area and establish the dynamic reservoir-forming process of natural gas. By combining the reserve data with the reservoir source distance, reservoir facies type, and gas filling times, the reservoir-forming and enrichment conditions are studied by statistical analysis method, and the reservoir-forming and enrichment rules are summarized by combining the main controlling factors. The enrichment of natural gas is controlled by the development degree of source rocks, favorable tight sandstone combination, confluence channel, and local structure. According to the law of accumulation and enrichment, the division standards of favorable areas in different horizons are established, and the favorable exploration areas in the study area are predicted. The results provide theoretical data support for natural gas exploration in the study area.

1. Introduction

With the continuous development of oil and gas industry, the large-scale exploitation of conventional oil and gas resources, and the increasing difficulty of limited conventional oil and gas resources, the development of unconventional oil and gas resources has been highly valued by the world. The reserves and output of unconventional oil and gas fields are increasing year by year in the oil and gas industry and have become the main resources for increasing oil and gas production in China and the world [1–4]. With the vigorous development of natural gas in China and the requirements of environmental protection, the status of natural gas in China's oil and gas exploration and development has been continuously improved, and the state has paid more and more attention to the exploitation and utilization of natural gas. Ordos basin, as a famous superimposed craton basin in China, is rich in natural gas in tight sandstone with low porosity and permeability [5–8]. At present, large, medium, and even super-large tight sandstone gas fields have been found in the Upper Paleozoic strata in the northern Ordos Basin in China. With the deepening of exploration and development of oil and gas blocks in the north of Ordos Basin, various gas fields are continuously put into production and output, and the growth rate of geological reserves of natural gas is accelerated, which makes the north of Ordos Basin the most favorable area for natural gas exploration and development, and to some extent, relieves the problem of natural gas production in China. Therefore, with the rapid development of society, the study of favorable exploration blocks for natural gas has become an important topic to meet the requirements of China's production protection and increase.

The formation of oil and gas reservoirs is the result of comprehensive action of various geological factors such as source rocks, reservoirs, traps, and migration. A good reservoir-cap combination, a good trap type, and favorable migration conditions are the most favorable combination to form gas reservoirs [9–12]. When judging the mode, conditions, and even exploration potential of natural gas reservoirs, the study of reservoir-forming conditions is the most critical. Some researchers divide reservoirs into four categories and study the characteristics of source rocks and traps [13–15]. Because of the ancient uplift belt in the central Ordos Basin, the trap type is buried hill type, so it can be confirmed that the natural gas accumulation conditions in the study area are good, which is beneficial to the accumulation of natural gas. Some researchers have studied the influence of faults on natural gas accumulation and believe that faults control natural gas accumulation, migration and accumulation, and traps dominated by tectonism [16–18]. By studying the characteristics of source rocks, reservoirs, caprocks, traps, and transportation systems in Junggar Basin, some researchers have found that the conditions of natural gas accumulation in this area are good, but the effectiveness of traps makes exploration and development more difficult. Some researchers believe that the gas accumulation mode in the study area is mainly source-controlled. By analyzing the gas source conditions such as the distribution characteristics and geochemical characteristics of source rocks, the characteristics of natural gas are studied. Combined with the sedimentary evolution history of the basin, the source rocks, reservoir characteristics, and migration characteristics in the study area are summarized, and the gas accumulation law is studied. According to the reservoir-forming geological conditions such as source rocks, traps, and migration characteristics, some researchers believe that the eastern part of Jungar Basin has a good source rock foundation, good reservoir-cap conditions, and good natural gas exploration potential and has divided it into three reservoir-forming models [19–22].

After determining the formation of oil and gas reservoirs in the study area, the oil and gas enrichment of oil and gas reservoirs will be the main research content. Oil and gas enrichment refers to the accumulation of oil and gas in traps, which can form large-scale and high-abundance oil and gas reservoirs. It is the most important stage of oil and gas reservoir formation research, and it is of great significance to guide oil and gas exploration. By studying the structural characteristics, sedimentary characteristics, source rock characteristics, and conductor characteristics of Ordos Basin, some researchers have come to the conclusion that faults are developed, source rock and reservoir conditions are well developed, and the landform is a trap caused by ancient uplift, which is a geological condition conducive to natural gas enrichment [23–25]. Some researchers have studied the development characteristics of faults in the source rocks of Shaximiao Formation in Zhongjiang Gas Field; analyzed the matching relationship between source rocks, reservoirs, and caprocks; and found that the conditions of source rocks and caprocks in this area are good, and the faults of source rocks play a double-sided role. Some researchers have studied the Shaximiao Formation gas reservoir and found that the interaction between faults and distributary channel sand and the effective plugging of ancient structures and channel sand are beneficial to the high yield and enrichment of natural gas. Some researchers have studied Dongpu Depression, analyzed the characteristics of two sets of source rocks and natural gas reservoirs, divided natural gas into coal-formed gas and condensate gas, and summarized their enrichment laws, respectively. The research results show that faults are beneficial to natural gas enrichment.

The conditions and enrichment law of tight sandstone gas reservoirs in the Upper Paleozoic in Ordos Basin have been studied to some extent, but the main problems of natural gas accumulation need further study because of the early research and low exploration degree. In this paper, the Upper Paleozoic tight sandstone in Hangjinqi area, north of Ordos Basin, is taken as the research object [26–29]. According to the geological characteristics of Ordos Basin, the gas accumulation conditions of tight sandstone are summarized, the main factors of gas accumulation are determined by superposition method, the dynamic process of gas accumulation is simulated, and the gas accumulation model is established. Through the combination of gas geological reserves and accumulation conditions, the gas accumulation and enrichment conditions are analyzed by statistical methods, the gas accumulation and enrichment rules are summarized, and the favorable exploration areas are predicted, thus providing theoretical data support for gas exploration in the study area.

2. Geological Features

Ordos Basin is generally located in the west-central region of China. The basin is generally rectangular, spreading from north to south, adjacent to Yinshan Mountain and Daqingshan Mountain in the north, bounded by Qinling Mountain in the south, connected to Luliang Mountain and Zhongtiao Mountain in the east, and extended to Helan Mountain and Liupanshan Mountain in the west [30–33]. The main research scope of this paper is Hangjinqi area, which is located in the northern part of Ordos Basin. The research area is composed of Hangjinqi and the western part of Hangjinqi, with an area of 6300 square kilometers and

Table 1: Characteristics of various strata in Hangjinqi area.

Stratum name	Stratigraphic characteristics
Taiyuan Formation	There is no sediment in the north of the fault, which is mostly in the south of the fault. The lithology is diverse, mud and sand are mixed, and coal seam and mudstone are well developed. It has strong hydrocarbon generation ability, which provides good source rock conditions for natural gas accumulation.
Shanxi Formation	It is later than Taiyuan Formation, and its distribution range is relatively large. The lithology has certain stratification characteristics in the vertical direction, with mudstone, coal seam, and a small amount of fine sandstone in the upper part. Coal seam and mudstone have certain influence on the natural gas accumulation in this area. The lower part is sandstone and glutenite, with relatively good reservoir properties, providing good reservoir conditions.
Xiashihezi Formation	Widely distributed on the plane, basically distributed in the whole study area. Vertically, it is composed of members 1, 2, and 3, and the lithology is mainly sandstone, mixed with a certain amount of mudstone. Lower Shihezi Formation sandstone has the best reservoir property and is the most important reservoir in this area.
Shangshihezi Formation	It is widely distributed on the plane, and its lithology is sandstone and mudstone. The mudstone has a large thickness, with a total thickness of over 100 meters, and it has a good sealing capacity, which provides a good capping condition for natural gas accumulation.
Shifeng Formation	It covers the whole area on the plane, and the lithology is mainly sandstone and mudstone. As a regional caprock, mudstone has a larger thickness and stronger sealing capacity.

3400 square kilometers, respectively. Ordos basin consists of six first-class structural units, mainly Yimeng uplift runs through the northern part of the basin, and the middle part is arranged from west to east into four structural units, namely, the western foreland thrust belt, Tianhuan depression, Yishan slope, and Jinxi fold belt, with Weibei uplift at the southernmost end.

2.1. Structural Features. There are mainly five secondary structural units in Hangjinqi area of Ordos Basin between Yimeng uplift and Yishan slope. Near-east-west faults are developed in the middle of the study area. The fault distance of Boerjianghaizi is large, and there are many vertical fault horizons, which have an important impact on the reservoir formation in this area [34–37]. At the same time, it can be divided into the southern part of the fault and the northern part of the fault according to the location of the fault. Different secondary structural units are affected differently by the distribution of faults. The southern part of the fault is Tianhuan syncline and Yishan slope with a very small area, and the northern part of the fault is Gongkahan uplift, Hangjinqi fault terrace, and Wulanger uplift, which are distributed in NW-SE direction.

2.2. Formation Characteristics. The horizons of natural gas exploration in Hangjinqi area are Carboniferous and Permian, which can be divided into Taiyuan Formation, Shanxi Formation, Xiashihezi Formation, Shangshihezi Formation, and Shiqianfeng Formation [38–40]. Table 1 shows the specific characteristics of each stratum in this area. The lithology of Taiyuan Formation and Shanxi Formation is diverse, and the coal seam and mudstone have strong hydrocarbon generation ability, which provide good source rock conditions for gas accumulation in this area. Sandstone and glutenite developed in Shanxi Formation and Xiashihezi Formation have relatively good reservoir properties, providing good reservoir conditions. Shanghezi Formation and Shiqianfeng Formation are all over the whole area on the plane, which provide a good caprock condition for gas accumulation.

3. Reservoir Forming Conditions and Enrichment Law of Tight Sandstone Gas

3.1. Reservoir Forming Conditions of Tight Sandstone Gas. The source rocks of Upper Paleozoic natural gas in Hangjinqi area mainly include Carboniferous Taiyuan Formation and Permian Shanxi Formation. The source rocks mainly include coal seam and mudstone, which are mainly developed in the transitional environment of land and sea, and belong to the strata deposited by land and sea. Identify mudstone, coal seam, and other source rocks on a single well by logging curves and core data. Using the Double Fox Software, the plane distribution map of coal seam and mudstone thickness of Taiyuan Formation in Hangjinqi area is drawn, and the distribution of source rocks is analyzed.

The thickness of source rocks in this area gradually becomes thinner from south to north, reaching the thinnest at the denudation line of Shanxi Formation and the thickest at the north of Boerjianghaizi fault. The source rocks are developed in the south and north of the Boerjianghaizi fault [41–44]. The thickness of the rock layer in the north of the fault is less than 10 m, but it is generally more than 10 m in the south. There are local high or low points in the north and south of the fault, which indicates that the fault has certain influence on the distribution of source rocks. The thickness of source rocks in the study area is about 8 ~ 26 m, which lays a solid material foundation for gas accumulation in this area.

Through experimental investigation, Figure 1 shows the mineral content of source rocks and Figure 2 shows the organic matter abundance of source rocks. It can be seen from Figure 1 that the main source rock minerals are clay minerals, accounting for about 45%, followed by Shi Ying and feldspar, accounting for more than 20%, and others are pyrite, calcite, dolomite, siderite, and other components. It can be seen from Figure 2 that the source rocks in the

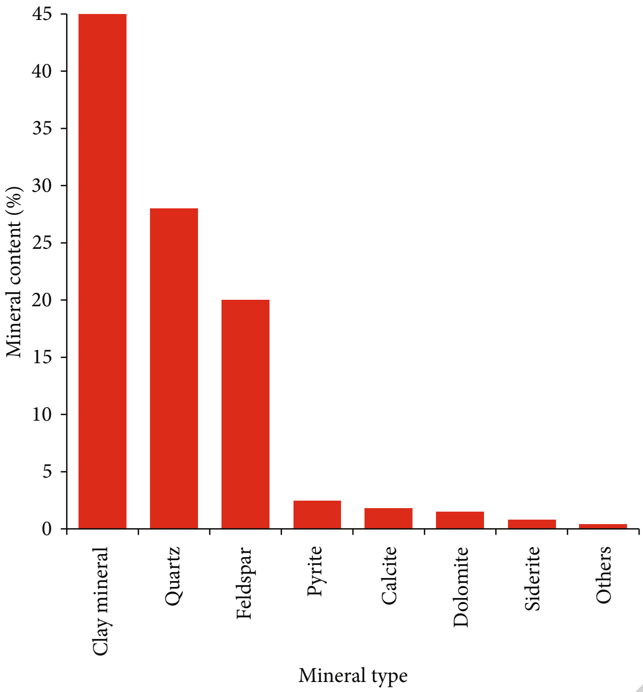

Figure 1: Mineral content of source rocks.

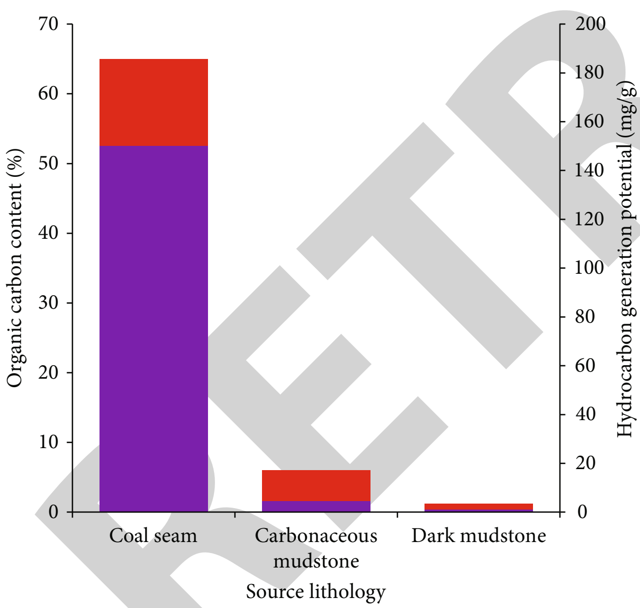

Figure 2: Abundance of organic matter in source rocks.

study area mainly include coal seam, carbonaceous mudstone, and dark mudstone, among which the highest organic carbon content is coal seam, which is between 60.4% and 77.3%, followed by carbonaceous mudstone, which is 3.2% to 8.6%, and dark mudstone, which is the lowest. At the same time, the hydrocarbon generation potential of coal seam exceeds 150 mg/g, the carbonaceous mudstone is 4.47 mg/g, and the dark mudstone is less than 1 mg/g. Therefore, it can be considered that the index of coal seam is far better than that of mudstone, and it is the most important source rock in the study area.

It is found that the Ro value of the source rocks in the study area gradually decreases from south to north, but it is over 1.2% on the whole, indicating that the source rocks have entered the stage of gas generation. At the same time, the Ro of the source rock in the northern part of the fault is about 1.2%, and its thermal evolution degree is low, which has not yet reached the peak of gas generation. Although it can provide a certain amount of natural gas, its output is insufficient. The Ro of the source rocks in the southern part of the fault area exceeds 1.4%, and it is already in the stage of massive gas generation, which is a good gas source in the study area. On the whole, the area of source rocks of upper gas is large, and the area of source rocks transporting natural gas to reservoirs is also large. The distance between the source rock and the reservoir is very close, and the migration distance is short, so it is easier to form gas reservoirs in the reservoir. The gas intensity of the Upper Paleozoic source rocks in the northern part of Ordos Basin has exceeded $109\ m^3/km^2$, which belongs to large and medium-sized gas fields. The gas intensity of the strata of the Upper Paleozoic coal measures in Hangjinqi area of the study area is between 5 and $35 \times 108\ m^3/km^2$, and the hydrocarbon generation conditions in the study area are good, so it is possible to become large and medium-sized gas fields.

The trap determines the natural gas reserves in the study area. In Shanxi Formation and Xiashihezi Formation in Hangjinqi area, channel sandstone and mudstone are interlaced, sandstone is the most suitable reservoir, mudstone provides a good cover and shelter condition for gas reservoirs, and this sedimentary feature is likely to develop lithologic traps. At the same time, the crisscross mudstone can be used as both caprock and source rock, and the full contact between source rock and reservoir has a great influence on gas accumulation. Rock traps are widely developed in the study area, mostly distributed in the southern part of the fault, while structural traps in the study area are also relatively developed, which are related to fault activities. The structural traps in the study area depend on the distribution of faults, forming local structural highs with high uplift amplitude, small area, and obvious trap elements, which are the best geological conditions for natural gas storage and allocation. Structural-lithologic compound trap is composed of drape structure and lithologic trap, mainly due to some ancient bulges on the basement of Paleozoic, which deposited on the ancient bulges and developed into drape structure, and laterally blocked by lithology to form favorable traps, which are generally distributed in the northern part of the fault.

The main channels of natural gas migration are connected sand bodies, fractures, cracks, etc. On the plane of the study area, the sand bodies are distributed in strips from north to south, with large thickness and wide distribution. On the section, the sand bodies have good continuity along the river channel. However, due to the different dredging capacity of sand bodies in different sections, the sand bodies in Shan 1 and He 1 are stable and continuous, and they are good lateral transport layers. The sand bodies in Shan 2, He

Table 2: Statistics of Tibetan-source distance in Upper Paleozoic.

Tibetan-source distance type	Near source	Yuannei	Yuan
Proportion (%)	65	11	24

2, and He 3 are thin, with poor continuity and weak lateral dredging force. Therefore, on the whole, the sand body in the study area has the characteristics of good continuity and strong stability and has good migration and transportation conditions in the north-south direction.

3.2. Enrichment Law of Tight Sandstone. The upper Paleozoic natural gas enrichment in the northern Ordos basin adopts statistical analysis method and studies the relationship between geological conditions such as reservoir-source distance, reservoir facies type, gas filling times, and natural gas enrichment degree and summarizes the natural gas enrichment law.

The upper Paleozoic gas source rocks in the northern Ordos Basin, which are mainly coal seams of Taiyuan Formation and Shanxi Formation, show a multicenter and extensive hydrocarbon generation pattern. This multicenter and extensive hydrocarbon generation pattern determines the different enrichment modes of natural gas, which makes the generation and enrichment characteristics of natural gas in Ordos Basin obvious. In the central hydrocarbon generation mode, due to the high hydrocarbon generation intensity, natural gas migrates to the upward direction of the structure. The relationship between hydrocarbon concentration enrichment and hydrocarbon generation distance shows a peak curve near the hydrocarbon generation center, and natural gas accumulates in the secondary structural belt or ancient uplift. On the whole, the central hydrocarbon generation model is characterized by close reservoir-source distance and centralized distribution.

Shanxi Formation in the study area belongs to the source type, which is close to the source rock, while XiaShihezi Formation in the south of Boerjianghaizi fault belongs to the near source type, while the natural gas in XiaShihezi Formation in the north of Boerjianghaizi fault belongs to the far source type. Table 2 and Figure 3 show the relationship between reservoir-source distance and natural gas enrichment in Paleozoic. It can be found that the reserves in the near source are the most; more than half, the reserves in the far source are the second, reaching about a quarter; and the reserves in the source are the least, less than 10%. On the whole, the study area is a reservoir in the near source type, which is conducive to natural gas enrichment.

In the study area, the delta depositional system is mainly developed in Shanxi Formation, and the alluvial fan depositional system and alluvial plain-braided river depositional system are developed in Xiashihezi Formation. Table 3 and Figure 4 show the Palaeozoic reservoir facies types and natural gas enrichment statistics. It can be found that the reserves of alluvial fan, alluvial plain-braided river reservoir facies account for more than 90% of the total reserves, while that of delta facies is only 10%, indicating that alluvial fan,

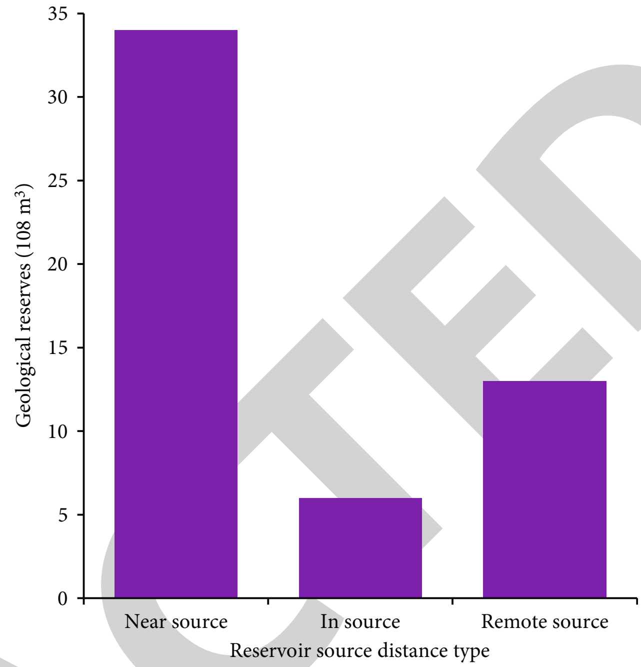

Figure 3: Geological reserves of natural gas at different reservoir-source distances in Upper Paleozoic.

Table 3: Statistics of Paleozoic reservoir facies types.

Reservoir facies type	Delta	Alluvial fan	Alluvial plain-braided river
Proportion (%)	89	9	2

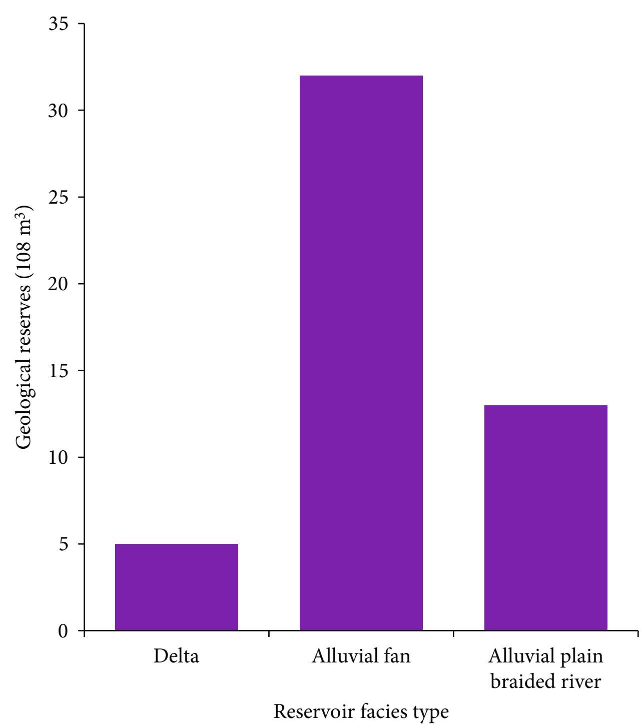

Figure 4: Geological reserves of natural gas at different reservoir-source distances in Upper Paleozoic.

Table 4: Prediction standard of favorable natural gas exploration area of Taiyuan-Shanxi Formation in study area.

Opinion rating	Hydrocarbon generation intensity (108/km^2)	Thickness of source rock (m)	Favorable sedimentary microfacies
Class I favorable area	≥20	≥30	Main branch river of delta
Class II favorable area	10~20	10~30	Sub-branch channel of delta
Class III favorable area	<10	<10	Sub-branch channel and crevasse fan in the plain

alluvial plain-braided river sedimentary facies are favorable reservoir facies.

There is a certain relationship between the filling times of natural gas and natural enrichment. Through statistical analysis, it is found that the geological reserves after two refills account for 75%, and the geological reserves after one refill account for 25%, indicating that multiple refills are more conducive to natural gas enrichment. The main reason is that the more natural gas is filled, the longer the filling time; the larger the amount of natural gas filled, the greater the probability of trapping natural gas, and the more reserves.

Through the investigation of natural gas in Taiyuan-Shanxi Formation in the study area, the investigation is focused on Shilijiahan area in the south of Boerjiang Haizi fault and Xinzhao area in the south of Sanyanjing fault. According to the investigation, the coal measure source rocks in the two areas are well developed, and the sand bodies in the east and west rivers are well developed. The lithologic traps are the main areas, and the reservoir is close to the gas source, and the sand bodies are obviously closed, which is conducive to the accumulation of natural gas. Therefore, Table 4 gives the prediction standard of natural gas favorable exploration area of Taiyuan-Shanxi Formation in the study area, thus determining that Xinzhao favorable area belongs to Class II favorable area, Shilijiahan has two favorable areas which belong to Class I favorable area, and a few belong to Class II favorable area.

4. Conclusion

The tight sandstone of Upper Paleozoic in Ordos Basin is characterized by low porosity, low permeability, and large area of concealed gas reservoirs. In order to find out the accumulation conditions of the Upper Paleozoic natural gas in the north of Ordos Basin, this paper takes the Upper Paleozoic tight sandstone in Hangjinqi area in the north of Ordos Basin as the research object, summarizes the gas accumulation conditions of tight sandstone according to the geological characteristics of Ordos Basin, determines the main control factors of gas accumulation by superposition method in combination with the distribution characteristics of natural gas, simulates the dynamic accumulation process of natural gas, establishes the gas accumulation model, and combines the geological reserves and accumulation conditions of natural gas. The statistical method is used to analyze the conditions of natural gas accumulation and enrichment, summarize the rules of natural gas accumulation and enrichment, predict the favorable exploration areas for natural gas, and provide theoretical data support for natural gas exploration in the study area. The main research results are:

(1) By investigating the source rock conditions, reservoir conditions, trap conditions, migration, and diversion conditions of the Upper Paleozoic natural gas in the study area, it is concluded that coal seam is the main source rock in the study area, the source rock of Shanxi Formation is superior to Taiyuan Formation vertically, and the source rock conditions in the southern part of the fault are superior to those in the northern part of the fault plane; There are lithologic traps, structural traps, and structural-lithologic compound traps in the study area. At the same time, connected sand bodies, faults, fractures, and unconformities constitute the migration channels of natural gas

(2) By investigating the relationship between geological reserves of natural gas and reservoir-source distance, reservoir facies types, and gas filling times, the conditions of gas accumulation and enrichment in the study area are studied by statistical analysis. As a whole, the near-source reservoirs in the study area, alluvial fan, alluvial plain-braided river sedimentary facies, the more times of gas filling, the more favorable it is for gas enrichment; The study determined that Xinzhao was a Class II favorable area. There are two Class I favorable areas in Shilijiahan, and a few of them belong to Class II favorable areas

Data Availability

The figures and tables used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

[1] L. Xing, Y. Xi, Z. Jiehui, and S. Honglin, "Reservoir forming conditions and favorable exploration zones of shale gas in the Weixin Sag, Dianqianbei Depression," *Dianqianbei Depression.*

Petroleum Exploration and Development, vol. 38, no. 6, pp. 693–699, 2011.

[2] Z. Wenzhi, W. Hongjun, X. Chunchun, B. Congsheng, W. Zecheng, and G. Xiaohui, "Reservoir-forming mechanism and enrichment conditions of the extensive Xujiahe Formation gas reservoirs, Central Sichuan Basin," *Petroleum Exploration and Development*, vol. 37, no. 2, pp. 146–157, 2010.

[3] Y. Yang, L. Wen, B. Luo et al., "Sedimentary tectonic evolution and reservoir-forming conditions of the Dazhou–Kaijiang paleo-uplift, Sichuan Basin," *Sichuan Basin. Natural Gas Industry B*, vol. 3, no. 6, pp. 515–525, 2016.

[4] L. O. N. G. Feng-Yu, Z. H. A. N. G. Jin-Chuan, L. I. Yu-Chi et al., "Reservoir forming conditions and strategic select favorable area of shale gas in the Lower Paleozoic of Chongqing and its adjacent areas," *Earth Science Frontiers*, vol. 19, no. 2, p. 221, 2012.

[5] J. Han, H. Cheng, Y. Shi, L. Wang, Y. Song, and W. Zhnag, "Connectivity analysis and application of fracture cave carbonate reservoir in Tazhong," *Science Technology and Engineering*, vol. 16, no. 5, pp. 147–152, 2016.

[6] K. Barker, "Rescuing remedialism in unjust enrichment law: why remedies are right," *The Cambridge Law Journal*, vol. 57, no. 2, pp. 301–327, 1998.

[7] B. Nicholas, "Unjustified enrichment in the civil law and Louisiana law," *Tul. L. Rev.*, vol. 36, p. 605, 1961.

[8] B. Dickson, "Unjust enrichment claims: a comparative overview," *The Cambridge Law Journal*, vol. 54, no. 1, pp. 100–126, 1995.

[9] P. Birks, "Annual Miegunyah lecture: equity, conscience, and unjust enrichment," *Melbourne University Law Review*, vol. 23, no. 1, pp. 1–29, 1999.

[10] P. W. Boyd, T. Jickells, C. S. Law et al., "Mesoscale Iron Enrichment Experiments 1993–2005: Synthesis and Future Directions," *Science*, vol. 315, no. 5812, pp. 612–617, 2007.

[11] W. Guanghui, L. Honghui, L. Zhang, W. Chenglin, and Z. Bo, "Reservoir-forming conditions of Ordovician weathering crust in the Maigaiti slope, Tarim Basin, NW China," *NW China. Petroleum Exploration and Development*, vol. 39, no. 2, pp. 155–164, 2012.

[12] Y. Xie, G. Zhang, Z. Sun, Q. Zeng, Z. Zhao, and S. Guo, "Reservoir forming conditions and key exploration technologies of Lingshui 17-2 giant gas field in Deepwater area of Qiongdongnan Basin," *Petroleum Research*, vol. 4, no. 1, pp. 1–18, 2019.

[13] Y. Hua, B. Hongping, and M. Zhanrong, "Reservoir-forming by lateral supply of hydrocarbon: a new understanding of the formation of Ordovician gas reservoirs under gypsolyte in the Ordos Basin," *Natural Gas Industry B*, vol. 1, no. 1, pp. 24–31, 2014.

[14] H. Cheng, Y. Dong, C. Lu, Q. Qin, and D. Cadasse, "Intelligent oil production stratified water injection technology," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 3954446, 7 pages, 2022.

[15] L. Liu, H. Rui, and L. Yang, "Definition of the Weihe single-thrusting compressional basin and its reservoir-forming conditions," *Northwestern Geology*, vol. 51, no. 2, pp. 186–202, 2018.

[16] H. Cheng, P. Ma, G. Dong, S. Zhang, J. Wei, and Q. Qin, "Characteristics of carboniferous volcanic reservoirs in Beisantai Oilfield, Junggar Basin," *Junggar Basin. Mathematical Problems in Engineering*, vol. 2022, pp. 1–10, 2022.

[17] Y. S. Z. S. F. Bingda and L. J. Y. N. X. Huaix, "Development characteristics of buried-hill and reservoir-forming pattern in central faulted structural belt of Jizhong Depression," *Acta Petrolei Sinica*, vol. 31, no. 3, p. 361, 2010.

[18] L. Deng and D. Yu, "Deep learning: methods and applications," *Foundations and trends® in signal processing*, vol. 7, no. 3–4, pp. 197–387, 2013.

[19] C. Zou, J. Jia, S. Tao, and X. Tao, "Analysis of reservoir forming conditions and prediction of continuous tight gas reservoirs for the Deep Jurassic in the Eastern Kuqa Depression, Tarim Basin," *Tarim basin. Acta Geologica Sinica-English Edition*, vol. 85, no. 5, pp. 1173–1186, 2011.

[20] B. Bin, Z. Rukai, W. Songtao et al., "Multi-scale method of nano(Micro)-CT study on microscopic pore structure of tight sandstone of Yanchang Formation, Ordos Basin," *Ordos Basin. Petroleum exploration and development*, vol. 40, no. 3, pp. 354–358, 2013.

[21] R. D. Thomas and D. C. Ward, "Effect of overburden pressure and water saturation on gas permeability of tight sandstone cores," *Journal of Petroleum Technology*, vol. 24, no. 2, pp. 120–124, 1972.

[22] Z. X. Jiang, Z. Li, F. Li et al., "Tight sandstone gas accumulation mechanism and development models," *Petroleum Science*, vol. 12, no. 4, pp. 587–605, 2015.

[23] H. Yin, J. Zhao, G. Tang, L. Zhao, X. Ma, and S. Wang, "Pressure and fluid effect on frequency-dependent elastic moduli in fully saturated tight sandstone," *Journal of Geophysical Research: Solid Earth*, vol. 122, no. 11, pp. 8925–8942, 2017.

[24] T. Guo, S. Tang, S. Liu et al., "Physical simulation of hydraulic fracturing of large-sized tight sandstone outcrops," *SPE Journal*, vol. 26, no. 1, pp. 372–393, 2021.

[25] B. Shi, X. Chang, W. Yin, Y. Li, and L. Mao, "Quantitative evaluation model for tight sandstone reservoirs based on statistical methods - a case study of the Triassic Chang 8 tight sandstones, Zhenjing area, Ordos Basin, China," *Journal of Petroleum Science and Engineering*, vol. 173, pp. 601–616, 2019.

[26] A. Reinicke, E. Rybacki, S. Stanchits, E. Huenges, and G. Dresen, "Hydraulic fracturing stimulation techniques and formation damage mechanisms– implications from laboratory testing of tight sandstone-proppant systems," *Geochemistry*, vol. 70, pp. 107–117, 2010.

[27] S. Yin and Z. Wu, "Geomechanical simulation of low-order fracture of tight sandstone," *Marine and Petroleum Geology*, vol. 117, article 104359, 2020.

[28] J. Cai, C. Li, K. Song et al., "The influence of salinity and mineral components on spontaneous imbibition in tight sandstone," *Fuel*, vol. 269, article 117087, 2020.

[29] W. Zhang, Z. Cheng, H. Cheng, Q. Qin, and M. Wang, "*Research of Tight Gas Reservoir Simulation Technology*," in *IOP Conference Series: Earth and Environmental Science*, vol. 804, IOP Publishing, p. 022046, 2021, July.

[30] Z. E. N. G. Zhiping, L. I. U. Zhen, M. A. Ji, Z. H. A. N. G. Chunlei, L. I. Jing, and S. U. N. Luning, "A new method for fracrability evaluation in deep and tight sandstone reservoirs," *Journal of Geomechanics*, vol. 25, no. 2, pp. 223–232, 2019.

[31] J. Sun, Q. Zheng, Z. Wen, F. Hou, R. Xiao, and J. Ren, "Shale gas reservoir-forming conditions and exploration prospect in permian Shanxi formation of the southern North China Basin," *Marine Geology Frontiers*, vol. 30, no. 4, pp. 20–27, 2014.

[32] L. Xianping, L. Xiaodong, T. Jianzhang et al., "Lithostratigraphic reservoir forming conditions and exploration potential in Langgu sag," *China Petroleum Exploration*, vol. 18, no. 6, p. 1, 2013.

[33] C. Yan-ping, H. Wen-hui, and L. Xiao-xia, "Shale gas reservoirĉ forming conditions in Qinshui Basin'sÁ marine-continental facies," *Resources and Industries*, vol. 15, no. 3, p. 68, 2013.

[34] L. Yuhong, S. Yingrui, Z. Likuan, M. Laicheng, C. Ming, and L. Naigui, "Research progress and development direction of reservoir-forming system of marine gas hydrates," *Acta Petrolei Sinica*, vol. 42, no. 6, p. 801, 2021.

[35] Z. Wang, "Reservoir forming conditions and key exploration and development technologies for marine shale gas fields in Fuling area, South China," *South China. Petroleum Research*, vol. 3, no. 3, pp. 197–209, 2018.

[36] H. Yang, X. Liu, X. Yan, and H. Zhang, "Discovery and reservoir-forming geological characteristics of the Shenmu Gas Field in the Ordos Basin," *Natural Gas Industry B*, vol. 2, no. 4, pp. 295–306, 2015.

[37] F. Wang, Y. Wang, X. Zhou et al., "Reservoir-forming conditions and key exploration & development techniques for Xushen gas field in Northeast China," *Petroleum Research*, vol. 4, no. 2, pp. 125–147, 2019.

[38] Z. Q. Gao, T. L. Fan, D. B. Liu, L. I. Yao, and M. L. Yu, "Reservoir-forming conditions of platform margin belt in southern slope of Tazhong, Tarim Basin," *Tarim Basin. Petroleum Exploration and Development*, vol. 35, no. 4, pp. 437–443, 2008.

[39] Z. H. A. O. Meng-jun and L. U. Shuang-fang, "Two periods of reservoir forming and their significance for hydrocarbon distribution in Kuqa Depression," *Acta Petrolei Sinica*, vol. 24, no. 5, p. 16, 2003.

[40] H. Cheng, J. Wei, and Z. Cheng, "Study on sedimentary facies and reservoir characteristics of Paleogene Sandstone in Yingmaili Block, Tarim Basin, *Tarim basin*," *Geofluids*, vol. 2022, Article ID 1445395, 14 pages, 2022.

[41] Z. Guo, X. Wang, and W. Liu, "Reservoir-forming features of abiotic origin gas in Songliao Basin," *Science in China Series D: Earth Sciences*, vol. 40, no. 6, pp. 621–626, 1997.

[42] M. Wang, H. Cheng, J. Wei, K. Zhang, D. Cadasse, and Q. Qin, "High-temperature-resistant, clean, and environmental-friendly fracturing fluid system and performance evaluation of tight sandstone," *Journal of Environmental and Public Health*, vol. 2022, no. 5, pp. 1–7, 2022.

[43] D. Liu, D. Ren, K. Du, Y. Qi, and F. Ye, "Impacts of mineral composition and pore structure on spontaneous imbibition in tight sandstone," *Journal of Petroleum Science and Engineering*, vol. 201, article 108397, 2021.

[44] L. I. Xia, L. I. Chaoliu, L. I. Bo, L. I. U. Xuefeng, and Y. U. A. N. Chao, "Response laws of rock electrical property and saturation evaluation method of tight sandstone," *Petroleum Exploration and Development*, vol. 47, no. 1, pp. 214–224, 2020.