Research Article

Characteristics of Tight Oil Reservoir Based on Nano-CT

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Besides biotechnology, nano-CT, the ideal technology, can also be used to observe three-dimensional nanostructures in intact cells as part of research into the characteristics of tight oil characteristics. There are few applications in the process and it is still in the early stage of development, but the advantages shown by 3D nanostructure technology are very strong and have strong applicability. Even in the face of tight oil reservoirs with poor physical properties, rapid decline in oil production after volume fracturing, and low oil recovery, it also shows very strong advantages. In order to promote the study of tight oil characteristics and avoid various problems, this article studies the characteristics of tight oil reservoirs based on nano-CT. The results show that the introduction of nano-CT technology into the study of tight oil reservoir characteristics can meet the market demand of tight oil and increase by 3.54%. It can continuously expand and develop rich oil resources under the condition of protecting geology and reservoirs, providing strong technical support for the next generation of large-scale tight oil storage and efficient growth, and can be used to a certain extent for research. The resulting reservoir characteristics solve the problem of excess resources.

1. Introduction

Tight oil development is a specific and complex project, hence it is necessary to prepare a work plan according to the characteristics of tight oil reservoirs in order to improve the production efficiency of tight oil, not only because tight oil reservoir is related to its utilization efficiency, but also because the current research technology of tight oil reservoir characteristics can easily destroy the reservoir characteristics, which is not conducive to the later production of tight oil. In addition, the current research on nano-CT technology and tight oil reservoir characteristics is relatively small, which cannot support the research on tight oil reservoir characteristics to a certain extent. The research on the characteristics of tight oil reservoirs based on nano-CT has great advantages.

Tight oil is a kind of oil that has been widely used and applied in recent years. However, due to the particularity of tight oil reservoirs, the exploitation of tight oil is not smooth, so more people are researching it. Based on the overall geological and geochemical evaluation, Fu X proposed the most important controlling factors for reservoir development and then explored favorable areas for strict petroleum exploration [1]. Jing S conducted a comprehensive analysis of the reservoir characteristics and thickening of the Jurassic Badaowan Formation in the Mosuowan-Mobei area of the Junggar Basin using core points and slice identification techniques [2]. In order to better guide the exploration and development of petroleum resources in this area, Bai Z studied the reservoir characteristics and control mechanism of low-contrast resistivity oil layers [3]. Based on elliptical flow theory, Zhu W established a comprehensive and practical multi-region-coupled flow mathematical model to characterize multi-scale flow and derived the pressure distribution equation [4]. Due to the inability to know the characteristics and formation mechanism of tight oil and gas reservoirs, Fan C used a series of analysis methods such as thin section, scanning electron microscope, and gas chromatography-mass spectrometry to study the tight reservoirs of the Xiagou Formation and the Zhonggou Formation [5]. In order to gain a general understanding of the enhancement of tight oil reservoir production by CO₂ huff and puff, Xia Z...
measured the high-pressure physical properties of typical tight oil samples [6]. Since it is difficult to classify the rock types and characterize the reservoirs in the marl interval, Cui J proposed a four-element classification method to determine the rock types by analyzing the mineral composition [7]. From this point of view, the current research results on the characteristics of tight oil reservoirs have been very rich, but few people realize the importance of nano-CT technology. Therefore, this article studies the characteristics of tight oil reservoirs based on nano-CT.

Since nano-CT is an effective technology to observe 3D cells in infinite cells, it is widely used in various fields. In order to better explore nano-CT technology, many teams have carried out research on it. R. S has developed an experimental protocol for time-lapse X-ray nanotomography imaging of environment-driven material morphological changes [8]. As crystallization is not yet fully understood about the mechanisms involved or the morphology of crystalline phase formation, Atc A demonstrated two cutting-edge imaging techniques including energy-dispersive X-ray spectroscopy and image correction including X-ray nanocomputed tomography [9]. The nanopore structure analysis of organic-rich shale is the basis for evaluating the reserves characteristics of shale reservoirs and the exploration and development potential of shale gas resources. To this end, Gou Q conducted nano-scanning and 3D reconstruction studies on the typical resources and connectivity of the Lower Silurian shale in the Longmaxi area of Jiaoshiba, Sichuan Basin [10]. Wafa M A E aimed to evaluate the effect of incorporating hydroxypatite nanorods into resin composite restorative materials and dental adhesives on the shear bond strength and interfacial micromorphology of dentin after storage in different media [11]. As cetuximab showed high target specificity and clinical promise in previous studies, Kuo WI formulated a high-specific activity and unit dose kit for imaging and treatment of positive cancers [12]. Taheri-Ledari R proposed a promising heterogeneous nanoscale catalytic system composed of chitosan, iron oxide nanoparticles, and copper oxide nanoparticles [13]. The aim of Alzimami K was to evaluate the imaging properties of standard tracers and to perform scanner comparisons with gold standard tracers in fluorodeoxyglucose imaging obtained using small animal standard tracers [14]. Although many people have been very rich in nano-CT research, few people realize that it is very meaningful to apply this technology to the exploration of tight oil. This article will combine the two.

Due to the characteristics of tight oil, it has become the focus and hot spot of people’s attention. However, because tight oil reservoirs are generally buried deep under the ground, it is difficult to understand the characteristics of tight oil reservoirs without destroying the surface. In order to solve this problem, this article studies the characteristics of tight oil reservoirs based on nano-CT technology.

2. Specific Content of Tight Oil Reservoir Characteristics

2.1. Evaluation Route of Tight Oil Reservoirs. In order to use nano-CT technology to study the characteristics of tight oil reservoirs [15], it is necessary to make a general evaluation of tight oil reservoirs, because only a certain degree of understanding of tight oil reservoirs is required first. Thereafter, the research route of tight oil reservoirs can be determined, and the characteristics of tight oil reservoirs can be further studied. For this reason, only the evaluation route of tight oil reservoirs are studied in this article [16]. The specific research route is shown in Figure 1.

As can be seen from Figure 1, the evaluation route of tight oil reservoir characteristics adopted in this article is mainly composed of two aspects: one is the reservoir, and the other is the pore structure. In the study of this reservoir and pore structure, the basic data of tight oil reservoirs, the actual photos of the field, and tight oil reservoir cores should be collected first; then special core sampling should be carried out for tight oil, the underlying geological conditions and institutional conditions in the exploration area and the availability of reservoir sedimentary physical characteristics should be determined, data support should be provided for subsequent evaluation, then research content should be designed, the research purpose should be determined on the basis of the collected data, and finally the samples should be prepared. Test and conduct experimental results analysis. In the reservoir part, mainly through the analysis of the lithological characteristics of the study area, combined with the fluorescence analysis data and the luminescence identification test, the reservoir physical properties of tight oil have been preliminarily understood. In the pore structure part, the characteristics of the pore system are studied and analyzed through the experimental data of casting thin sections and SEM and CT scanning, and then the characteristics of tight oil reservoirs are calculated in detail according to the design and duration of the mercury intrusion extraction method. It lays a solid theoretical foundation and technical support for the study of tight oil reservoir characteristics based on nano-CT [17].

2.2. Tight Oil Reservoir Characteristics. Only evaluating tight oil reservoirs [18] will lead to the study of tight oil reservoir characteristics staying in theory and one-sided cognition, which will lead to deviations in the characteristics research of tight oil. In order to solve this problem, in this article, the research route for tight oil reservoir characteristics has been determined, and the specific research route is shown in Figure 2.

It can be seen from Figure 2 that the research route of tight oil reservoir characteristics adopted in this article is mainly composed of two parts: one component is the study of physical properties of tight sandstone reservoirs, and the other component is tight sandstone reservoir seepage stimulation. In the whole research line of tight oil reservoir characteristics, the main plan of this article is to select natural particles from the dense sand dunes along a certain oil field for a detailed experimental study. In the research part of the physical properties of tight oil reservoirs, first, gas pressure and measurement experiments are carried out on matrix cores, and artificial-matrix dual-medium cores are obtained by manual operation. Permeability inspection and the bifurcation operation are performed on the core of the
study the characteristics of tight oil reservoirs by general
the naked eye and general measurement tools, let alone to
the ground [19], which cannot be identified and explored by
Generally, special oils such as tight oil are deeply buried in
2.3. Modeling of 3D Tight Oil Geological Model.

double matrix, and then the artificial flow matrix is obtained. The variation law of permeability of double-medium pressure cores was studied by manometric method. At the same time, the mercury intrusion method should be used to measure parameters such as pore neck radius, neck distribution characteristics, selectivity coefficient, and slope of solid sand grains in order to provide specific data for the study of tight oil reservoir characteristics. In the experimental part of the seepage device for tight oil reservoirs, the steady dynamic method is used to start the seepage pressure gradient, and the simulation data processing method of the pressure gradient is added to the movement engineering of the relative permeability, so as to facilitate the oil-water relative permeability of dual-medium cores degree test. After analyzing the reasons for the dynamic imbibition of tight oil reservoirs, the influence of different influencing factors on the characteristics of tight reservoirs can be studied.

2.4. Physical Simulation Experiment of Dynamic Imbibition. It is limited to study the reservoir characteristics of tight oil only theoretically [21]. If you want to obtain specific and practical research data, you must start from the actual situation, but generally, the actual scene is too large and affects too many factors, which will also affect the specific research on the characteristics of tight oil reservoirs. Therefore, this article studies the physical simulation experiment of dynamic imbibition. The specific simulation experiment process is shown in Figure 4.

As can be seen from Figure 4, in order to conduct regular drills under the high temperature and high-pressure conditions of tight oil reservoirs and reflect the differential characteristics of the pressure system in the energy amplification and release process of the oil production system, the dynamic imbibition physical simulation experiments studied in this article mainly use the dynamic huff, puff, and imbibition experimental method, which involves two small processes of static absorption and decompression backflow in each large process of expansion and contraction. The core of a tight oil reservoir will first complete the absorption under the forming pressure. The static displacement of the medium and the oil phase and then the decompression and reflux of the core will bring oil up through the imbibition medium. This dynamic imbibition simulation process
requires multiple transitions until no oil is discharged. The application equipment of the dynamic osmotic absorption simulation experiment mainly includes confining pressure pump, pressure relief pump, high-pressure pump, intermediate container, constant temperature box, high-pressure suction chamber, back pressure valve, pressure gauge, and precision oil separator. In addition, according to the functional characteristics of each component in the dynamic penetration and absorption test, these devices can be divided into four parts: the driving part, the control part, the high-pressure suction part, and the isolation part. The HPHT dynamic permeation absorption simulator can perform well under HPHT conditions and perform a range of energy technologies such as permeation, absorption, and impact assessment on the way energy is replenished. The flow part adopts the independent form of the calculation part and the high-pressure imbibition part to ensure that the pressure change of the high-pressure suction chamber in the process of inflation, suction, and absorption will not affect the measurement of dissolved water and the progress of accurate measurement. The precision oil-water separator can realize the simultaneous measurement of oil and avoid the accumulation of liquid errors in the process of multi-tube inflation, liquid absorption, and liquid immersion [22].

2.5. Formation Process of Tight Oil. When it comes to the study of reservoir characteristics of tight oil, it is inseparable from the study of the formation process of tight oil [23], because tight oil can only be formed under specific conditions, and the formation process of tight oil includes changes in its reservoir characteristics. Therefore, in order to deeply study the characteristics of tight oil reservoirs, it is necessary to study the formation process in detail. The specific formation process is shown in Figure 5.

As can be seen from Figure 5, the geology of tight oil areas is divided into many layers, and different geological layers have different formation backgrounds and conditions, so the formation conditions of tight oil in different rocks are also different, that is the formation of tight oil requires three basic conditions: the first is the large-scale distribution of tight oil reservoirs, the second is a moderately mature dispersed sapropel-type high-quality oil source layer, and the third is a symbiotic layer in which a widely distributed tight oil reservoir is combined with a nearby source rock. The reason why these three conditions are the key to the formation of tight oil is that tight oil needs to be sandwiched in or close to high-quality oil source layers formed in the tight reservoirs of the system without large-scale long-distance migration. In terms of tight reservoirs, eight out of the nine lithological segments in geology are tight reservoirs. The center of the main reservoir is the dolomite shale formed in the coastal areas under the outer continental shelf. When the tight oil reservoirs are distributed in a large area, it will cause a large number of tight oil layers to be distributed on the plane on a large scale. In terms of sapropel-type high-quality oil-generating layers, two sets of shale layers with a thickness of more than 10 m are developed in tight oil, so the total organic carbon content of this rock layer is high, and it is the peak period for the formation of tight oil. In terms of the symbiotic layer, the source rocks above and below the tight oil reservoirs are distributed in a large area, so the formation conditions of tight oil in different rocks are different, that is the formation of tight oil requires three basic conditions: the first is the large-scale distribution of tight oil reservoirs, the second is a moderately mature dispersed sapropel-type high-quality oil source layer, and the third is a symbiotic layer in which a widely distributed tight oil reservoir is combined with a nearby source rock. The reason why these three conditions are the key to the formation of tight oil is that tight oil needs to be sandwiched in or close to high-quality oil source layers formed in the tight reservoirs of the system without large-scale long-distance migration. In terms of tight reservoirs, eight out of the nine lithological segments in geology are tight reservoirs. The center of the main reservoir is the dolomite shale formed in the coastal areas under the outer continental shelf. When the tight oil reservoirs are distributed in a large area, it will cause a large number of tight oil layers to be distributed on the plane on a large scale. In terms of sapropel-type high-quality oil-generating layers, two sets of shale layers with a thickness of more than 10 m are developed in tight oil, so the total organic carbon content of this rock layer is high, and it is the peak period for the formation of tight oil. In terms of the symbiotic layer, the source rocks above and below the tight oil sandwich the tight reservoir, forming a good source-reservoir adjacency configuration.

3. Utilization Algorithm of Tight Oil Reservoir Characteristics

(1) Total energy of nanoparticles. Nanoparticles are of great scientific value because they bridge the link between matter and the mass of atoms and molecules [24], the total energy of which is calculated as

$$E = \sum_{i} s \left[ \sum_{j \neq i} \frac{1}{2} V(r_{ij}) - c \sqrt{P_{i}} \right],$$  \hspace{1cm} (1)

where \(s\) is the scaling factor of the energy and \(c\) is the dimensionless parameter.

(2) Local charge density

$$V(r_{ij}) = \left( \frac{a}{r_{ij}} \right)^n p_{i} = \sum_{i \neq j} a(r_{ij}) = \left( \frac{a}{r_{ij}} \right)^n,$$  \hspace{1cm} (2)

where \(a\) is the lattice parameter and \(n\) is a constant and an integer.

(3) Interaction parameters
where $i$ and $j$ represent two different types of atoms, respectively.

4. Fitness function

$$ F_i = \exp \left( -p \frac{v_i - v_{\min}}{v_{\max} - v_{\min}} \right), $$

where $F_i$ represents the fitness value of individual configuration and $p$ represents the scale factor.

5. Atomic core distance

$$ RA = \frac{1}{nA} \sum_r r_i, $$

where $RA$ is the average distance of A-type atoms, and $nA$ is the total number of A-type atoms.

6. Solving the optimization function, we have

$$ \min f(x), x = x_k, \min f(x) = f(x_k), $$

where $f(x)$ represents the optimization objective function to solve the problem, and $x$ represents the optimization vector in the D-dimensional space.

7. Particle displacement

$$ V_{ik} = wV_{ik} + c_n r_m (P_{ik} - X_{ik}) = X^t_{ik} + V_{ik}, $$

where $X_{ik}$ is the coordinate of the position of the $i$th particle in the $k$ dimension.

8. Particle position and velocity

$$ X^t_i = X^t_{1D}, i = 1, 2, \ldots, m $$

$$ V^t_i = V^t_{1D}, t = 1, 2, \ldots, g, $$

where $m$ is the size of the particle population, and $t$ is the evolutionary algebra.

9. Solution space vector. The coordinates of each dimension of the vector of the solution space should be located between its specified upper and lower bounds, and its calculation formula is as follows:

$$ X^t_{ik} = \begin{cases} l_k, & \text{if } X^t_{ik} < l_k, \\ u_k, & \text{if } X^t_{ik} < u_k, \\ X^t_{ik}, & \text{other}. \end{cases} $$

10. Particle limited speed. The speed of particles is also limited within a certain range [25], and its calculation formula is as follows:

$$ V^t_{ik} = \begin{cases} -V_m, & \text{if } V^t_{ik} < -V_m, \\ V_m, & \text{if } V^t_{ik} > V_m, \\ V^t_{ik}, & \text{other}. \end{cases} $$

11. Optimal position

$$ p^t_i = X^t_i, $$

12. Fuzzy function

$$ S(V^t_{ik}) = \frac{1}{1 + \exp \left( -V^t_{ik} \right)}, $$

where $S$ is the fuzzy function.
5.1. Comparative Analysis of the Characteristics of Reservoirs

5. Experimental Study on the Characteristics of Tight Oil Reservoirs

4. Tight Couple Reservoir Characteristics

4.1. Literature Research Method. The literature research method is currently the most widely used method of data investigation. It can obtain relevant data through limited data and lay a solid theoretical foundation for its investigation. The relevant information of tight oil reservoirs and characteristics has laid a solid theoretical foundation for the later writing of this article.

4.2. Data Collection Law. The data collection method is to integrate the relevant data into the required data on the basis of certain theories and data sources, so as to facilitate the utilization and application of the data. In order to facilitate research and analysis, this article studies and analyses different oils, different reservoirs, and different reservoir characteristics together, so as to obtain corresponding data. For the convenience of identification, this article names the different oils as Oil 1, Oil 2, Oil 3, Oil 4, and Oil 5 and names the different technologies as Technology 1, Technology 2, Technology 3, Technology 4, and Technology 5. Among them, Oil 5 is the tight oil and Technology 5 is the nano-CT technology studied in this article.

4.3. Data Analysis Method. Data analysis is the process of studying and summarizing data in detail in order to extract useful information and form conclusions. Since the data collected through various methods cannot be applied to practice to a certain extent, this paper provides a detailed analysis of the collected data, so as to facilitate the conclusion and research of the results.

5. Experimental Study on the Characteristics of Tight Oil Reservoirs

5.1. Comparative Analysis of the Characteristics of Reservoirs Where Different Oils Are Located. If we only study the characteristics of tight oil from a single aspect, the data will be too single, and it is difficult to study the characteristics of tight oil reservoirs in detail from multiple aspects. In order to solve this problem, this article first analyzes the characteristics of different oils. The comparison and analysis were carried out, and the specific data are shown in Figure 6.

As can be seen from Figure 6, this article mainly compares and analyzes the characteristics of different oil reservoirs from seven aspects, including distribution area, accumulation mechanism, pore structure, interstitial material, exploration difficulty, depositional environment, and rock thickness. In terms of distribution area, the scores of Oil 1 and Oil 2 are only more than 5.5 points, which are the two lowest distribution areas among all oils, indicating that these two oils are not suitable for large-scale exploitation. In terms of accumulation mechanism, the fraction values of Oil 4 and Oil 5 are the lowest among all oils, indicating that the accumulation mechanism of these two oils is relatively obvious. In terms of pore structure, the scores of Oil 1, Oil 2, and Oil 3 are below 6 points, indicating that the pore structure characteristics of these three kinds of oils are relatively inconspicuous and difficult to be explored by various tools. In terms of shims, Oil 1 and Oil 2 have the lowest scores, indicating that the shim characteristics of these two oils are not as pronounced as those of the other oils. In terms of exploration difficulty, the score of Oil 5 is below 5, which is the most difficult to explore among all oil types, indicating that nano-CT technology is more suitable for studying the characteristics of tight oil reservoirs. In terms of sedimentary environment, the scores of Oil 1 and Oil 2 are between 5 and 6, which is the worst sedimentary environment among all oils, and the yield will be relatively low. In terms of rock layer thickness, the scores of Oil 3, Oil 4, and Oil 5 are relatively high among all oils, indicating that the rock layer thickness characteristics of these three oils are more obvious among all oils and it is easier for machines to explore. On the whole, except for the difficulty of exploration, the characteristics of Oil 5 are the easiest to discover and it is also the most obvious of all oils.

5.2. Exploration Efforts of Different Technologies for Tight Oil Reservoir Characteristics. When studying the characteristics of tight oil, various technologies will be introduced into the study. However, because different utilization technologies have different characteristics and functions, there will be inconsistencies when studying the characteristics of tight oil reservoirs. With the same exploration effect, in order to further study the characteristics of tight oil reservoirs based on nano-CT, this article mainly studies the exploration efforts of different technologies on the characteristics of tight oil reservoirs in detail. The specific data are shown in Figure 7.

As can be seen from Figure 7, when studying the exploration efforts of different technologies on the characteristics of tight oil reservoirs, it is mainly studied from six aspects: distribution area, saturation, burial depth difference, pressure anomaly, displacement span, and mineral content. In terms of distribution area, the exploration intensity of Technology 1 is the lowest, only over 6 points, while the exploration intensity of Technology 2 and Technology 5 is relatively high, as high as about 9 points, indicating that Technology 2 and Technology 5 are paired. The exploration efforts in the distribution area of tight oil reservoirs are relatively low. In terms of saturation, the scores of Technology 1 and Technology 2 are the lowest compared to the other three technologies, and their scores are less than 5 points, indicating that these two technologies have relatively low
5.3. Comparison and Analysis of Different Reservoir Characteristics. Since the production of tight oil has little to do with the properties of the rock formation, as long as each rock formation meets the conditions for tight oil production, it can become a tight oil reservoir, but the possibility of producing tight oil in different rock formations will be different. When nano-CT technology is used to study the characteristics of tight oil reservoirs, it is necessary to conduct related research on different reservoirs. The specific data are shown in Figure 8.

It can be seen from Figure 8 that different tight oil reservoirs are mainly divided into seven types: sandstone, glutenite, limestone, dolomite, sedimentary, transitional, and other rock formations. In the sandstone reservoir, the scores of Technology 1 and Technology 2 are lower than those of the other three, and the lowest score is only about 5 points, which shows the characteristics of these two technologies in the exploration of sandstone reservoirs are lower. In glutenite reservoirs, the scores of Technology 2, Technology 4, and Technology 5 are much higher than those of the other two technologies, which also shows that these three technologies have better performance in the characteristic survey of glutenite reservoirs. In limestone reservoirs, the scores of Technology 1, Technology 2, and Technology 4 are below 7.5 points, which is far lower than the other two technologies, indicating that these three technologies are the most important characteristics of limestone reservoirs among all technologies. The exploration effect is relatively poor. In dolomite reservoirs, the scores of Technology 3, Technology 4, and Technology 5 are much higher than the other two technologies, indicating that these three technologies have better effects in exploring the characteristics of dolomite reservoirs. In sedimentary rock reservoirs, except for Technology 5, the scores of the other four are basically below 8.5, which is far less than that of Technology 5 with scores above 9.5. These four technologies have relatively poor exploration effects on the characteristics of sedimentary rock reservoirs and cannot meet the needs of today’s society. In the reservoirs of transitional rocks and other rocks, the scores of Technology 1, Technology 2, and Technology 3 are all relatively poor, indicating that these three techniques are not suitable for the study of the characteristics of transitional and other rock reservoirs. On the whole, the exploration effect of Technology 5 on different reservoir characteristics is relatively good.

5.4. Comparison and Analysis of Different Reservoir Characteristics under Nano-CT. If we only start with the study of different reservoirs with different technologies, it is relatively single and one-sided, or we need to study the characteristics of different reservoirs based on nano-CT, so as to ensure the comprehensiveness of the research on the characteristics of tight oil reservoirs. Nano-CT has carried out a detailed comparison and analysis of different reservoir characteristics, and its specific data are shown in Figure 9.

It can be seen from Figure 9 that the comparison and analysis of the characteristics of different reservoirs mainly...
start from six parts, including porosity, permeability, anomalous fractional pressure, homogeneity coefficient, core index, and distribution area. In terms of sandstone reservoirs, the proportion of its distribution area is relatively low, only about 50%, and its permeability is the highest, up to about 95%, indicating that the distribution area characteristics of sandstone reservoirs are the weakest. And its permeability characteristic is the highest. In terms of conglomerate sandstone reservoirs, except for the abnormal pressure and distribution area, the characteristics are relatively strong, because the proportion of these two parts is the highest compared with the other four aspects, which also shows that this part is the most salient of all sections. In terms of limestone reservoirs, its homogeneity coefficient has a very obvious downward trend, and it is the lowest proportion of all parts, which also shows that the mean coefficient of limestone reservoirs is relatively poor. In terms of dolomite reservoirs, its pressure anomaly characteristics are the lowest compared to the other three methods, only about 59%, indicating that its pressure anomaly characteristics are very unfavorable for research. In the sedimentsay tuff reservoir, except for the characteristics of the fractional fugitive value, other characteristics are concentrated in about 80%, indicating that the effect of nano-CT in its fractional fugitive value is relatively poor. In transitional rock reservoirs and other rock reservoirs, their pressure anomaly, homogeneity coefficient, and distribution area are relatively high and concentrated, indicating that these characteristics account for the majority of transitional rock reservoirs and other rock reservoirs. The ratio is relatively high. On the whole, different reservoirs under nano-CT have different characteristics and are easy to distinguish.

5.5. Comparative Analysis of Actual and Predicted Reservoir Characteristics. Nano-CT refers to an ideal technology for observing three-dimensional nanostructures in intact cells. As the name implies, nano-CT is a pure theory, not a field inspection technology. Therefore, there is a certain gap between the characteristic data of tight oil reservoirs based on nano-CT and the actual situation. In order to better understand the nano-CT technology, the characteristics of tight oil reservoirs are studied in detail. This article conducts a specific study on the comparison and analysis of the actual and predicted reservoir characteristics. The specific data are shown in Figure 10.

As can be seen from Figure 10, this article mainly compares and analyzes the actual and predicted reservoir characteristics from seven aspects, including porosity, permeability, pressure anomaly, homogeneity coefficient, distribution area, depositional environment, and rock thickness. In terms of porosity characteristics, the data observed based on nano-CT technology are about 8–8.5 points, which is about 1 point different from the data of actual tight oil reservoir characteristics, indicating that nano-CT is not very suitable for studying porosity characteristics. In terms of permeability characteristics, the actual exploration data are about 8.1 points, and the data observed based on nano-CT are very similar to the actual exploration data, indicating that nano-CT can obtain the permeability of tight oil reservoirs. In terms of abnormal pressure characteristics, the difference between the data observed by nano-CT and the actual survey data is about 0.5 points, indicating that there is still a certain gap between the data observed by
nano-CT technology and the actual situation. In terms of characteristics of the homogeneity coefficient, the data observed based on nano-CT are 9.7 points, but the actual homogeneity coefficient is only about 9.1 points, indicating that the data observed based on nano-CT still deviate greatly from reality. Estimation errors are prone to occur when studying this feature. In terms of distribution area and sedimentary environment characteristics, the actual exploration data are higher than the data observed based on nano-CT, but the difference with the nano-CT data is not very big, indicating that these two characteristics observed based on nano-CT have great utility in terms of data. In terms of rock thickness characteristics, the data observed based on nano-CT are very close to the actual characteristics of the survey data, indicating that nano-CT can be well used to study the rock thickness characteristics of tight oil reservoirs. Overall, it is of great practical significance to introduce nano-CT into the study of tight oil reservoir characteristics.

6. Characteristics of Tight Oil Reservoirs

Under the background of the vigorous improvement in the quality and efficiency of tight oil development, the current low-energy-consumption tight oil and gas resources account for an increasing share of the overall energy growth. Because the low-permeability oil and gas resources are very rich and widely distributed, they are the main oil and gas reservoirs that must be quickly utilized in the energy process. However, due to the serious problems of poor reservoir physical properties and small pore throats in the development process of tight oil, traditional development technologies can only achieve high recovery and high productivity in the early stage of development and cannot achieve long-term stable production and creation, resulting in low ultimate recovery of low-permeability crude oil and cause serious geological damage. In order to solve these problems, the characteristics of tight oil reservoirs are studied in detail based on nano-CT.

(1) The characteristics of the reservoirs where different oils are located are compared and analyzed. The research results show that the fractional values of Oil 1 and Oil 2 are relatively small in terms of distribution area characteristics. Oil 4 and Oil 5 have obvious characteristics in terms of accumulation mechanism. Oil 1, Oil 2, and Oil 3 have different pore structures. The characteristics are relatively inconspicuous, and it is difficult to use various tools to explore them. Oil 1 and Oil 2 are not as obvious in terms of interstitial properties as other oils. Oil 5 is the most difficult to explore among all oils, and is more suitable for nano-CT technology to study its characteristics. Oil 1 and Oil 2 have the worst depositional environment among all oils. Oil 3, Oil 4, and Oil 5 have the most obvious characteristics in terms of rock layer thickness among all oils. On the whole, aside from exploration difficulty, Oil 5 is the most characteristic of all oils.

(2) The exploration efforts of different technologies in tight oil reservoir characteristics were studied. The research results show that the exploration intensity of Technology 1 is the lowest in terms of distribution area, while the exploration intensity of Technology 2 and Technology 5 is relatively high. The exploration intensity of tight oil reservoir saturation with Technology 2 is relatively low. The exploration and research efforts of Technology 2 in the difference of burial depth of tight oil reservoirs are far less than other technologies. The investigation strength of Technology 2 and Technology 4 in the formation pressure anomaly is relatively poor. The investigation strength of Technology 1, Technology 3, and Technology 5 on the displacement span of tight oil reservoir is not as good as the other three techniques. Technology 4 and Technology 5 can well study the mineral content characteristics of tight oil reservoirs.

(3) The exploration effect of different technologies in different reservoir characteristics is studied. The research results show that Technology 1 and Technology 2 have relatively low effects on the characteristics of sandstone reservoirs. Technology 2, Technology 4, and Technology 5 have relatively good results on the characteristics of sandstone reservoirs. Among all technologies, the exploration effect of limestone reservoir characteristics is relatively poor. Technology 3, Technology 4, and Technology 5 have relatively good results in the exploration of dolomite reservoir characteristics. The four technologies except Technology 5 have a better effect on sedimentation and condensation. The exploration effect of rock reservoir characteristics is relatively poor. Technology 1, Technology 2, and Technology 3 are not suitable for the study of transition rock and other rock reservoir characteristics. On the whole, Technology 5 is not suitable for different reservoirs. The exploration effect of the features is relatively good.
(4) The characteristics of different reservoirs under nano-CT are compared and analyzed. The research results show that the distribution area characteristic of sandstone reservoir is the weakest, and its permeability characteristic is the highest. The pressure anomaly and distribution area part of the gravel sandstone reservoir are relatively strong. The uniformity of limestone reservoir is relatively strong. The quality coefficient is the lowest among all the parts. The pressure anomaly characteristics of dolomite reservoirs are the lowest compared with the other three methods. The effect of sedimentary tuff reservoirs on the characteristics of outliers is relatively poor. Transition rock reservoirs and other rock reservoirs have obvious and concentrated features such as pressure anomalies, homogeneity coefficients, and distribution areas. On the whole, different reservoirs under nano-CT have different characteristics and are easy to distinguish.

(5) The actual and predicted reservoir characteristics are compared and analyzed. The research results show that the porosity characteristic data observed based on nano-CT technology are different from the actual tight oil reservoir characteristic data by about 1 point, and the gap is relatively large. The data are very similar. The characteristic data of pressure anomalies observed based on nano-CT still have a certain gap with the actual. The characteristic data of homogeneity coefficient observed based on nano-CT have a great deviation from the actual. Based on nano-CT, the observed data on the distribution area and the characteristics of the depositional environment are of great practicability. Nano-CT can be used to study the rock thickness characteristics of tight oil reservoirs to a certain extent. It is of great practical significance to be introduced into the study of tight oil reservoir characteristics.

7. Conclusion

Although the current research on the characteristics of tight oil reservoirs has a certain degree of complexity, it plays a crucial role in the current development and progress of tight oil. The development of innovation and raw material technology has laid a solid foundation for the development and progress of tight oil companies. At the same time, by dealing with new material innovation, oil layer innovation, information technology innovation, biotechnology innovation, etc., we can accelerate the successful development of tight oil chemical industry. In order to promote the research and development of tight oil, this article studies and analyzes the characteristics of tight oil reservoirs in detail based on nano-CT. The exploration intensity, the exploration effect of different technologies in different reservoir characteristics, the characteristics of different reservoirs under nano-CT, and the actual and predicted reservoir characteristics are compared and analyzed. The research results show that, in addition to the difficulty of exploration, the characteristics of tight oil are the most obvious of all oil types. Technology 5 is not only very suitable for exploring the characteristics of tight oil reservoirs, but also the exploration effect of different reservoir characteristics is comparable. Well, in addition, different reservoirs under nano-CT have different characteristics and are easy to distinguish, and it is of great significance to introduce nano-CT into the study of the characteristics of tight oil reservoirs. Of course, there are still some shortcomings in this article, which will be continuously developed and improved in the later stage.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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