Geological characteristics and “sweet area” evaluation for tight oil

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Abstract Tight oil has become the focus in exploration and development of unconventional oil in the world, especially in North America and China. In North America, there has been intensive exploration for tight oil in marine. In China, commercial exploration for tight oil in continental sediments is now steadily underway. With the discovery of China's first tight oil field—Xin'anbian Oilfield in the Ordos Basin, tight oil has been integrated officially into the category for reserves evaluation. Geologically, tight oil is characterized by distribution in depressions and slopes of basins, extensive, mature, and high-quality source rocks, large-scale reservoir space with micro- and nanopore throat systems, source rocks and reservoirs in close contact and with continuous distribution, and local “sweet area.” The evaluation of the distribution of tight oil “sweet area” should focus on relationships between “six features.” These are source properties, lithology, physical properties, brittleness, hydrocarbon potential, and stress anisotropy. In North America, tight oil prospects are distributed in lamellar shale or marl, where natural fractures are frequently present, with TOC > 4 %, porosity > 7 %, brittle mineral content > 50 %, oil saturation of 50 %–80 %, API > 35°, and pressure coefficient > 1.30. In China, tight oil prospects are distributed in lamellar shale, tight sandstone, or tight carbonate rocks, with TOC > 2 %, porosity > 8 %, brittle mineral content > 40 %, oil saturation of

60 %–90 %, low crude oil viscosity, or high formation pressure. Continental tight oil is pervasive in China and its preliminary estimated technically recoverable resources are about $(20\text{--}25) \times 10^8$ t.

Keywords Tight oil · Geological features · “Sweet area” evaluation · Tight reservoirs · Unconventional oil and gas · Shale oil

1 Introduction

Tight oil refers to the oil preserved in tight sandstone or tight carbonate rocks with overburden pressure matrix permeability less than or equal to $0.1 \times 10^{-3} \mu\text{m}^2$ (air permeability less than $1 \times 10^{-3} \mu\text{m}^2$). Individual wells generally have no natural productivity or their natural productivity is lower than the lower limit of industrial oil flow, but industrial oil production can be obtained under certain economic conditions and technical measures (Jia et al. 2012a, b; Zou et al. 2012; Hao et al. 2014). Such measures include acid fracturing, multi-stage fracturing, horizontal wells, and multi-lateral wells. Tight oil is a highlight in global unconventional oil, for which industrial breakthroughs have been achieved in North America. Tight oil reservoirs, as typical “man-made” oil reservoirs, are explored and developed by vertical well network fracturing and horizontal well volume fracturing in order to form “man-made permeability” and achieve substantial productivity. In this article, through case studies based on the tight oil practices in North America and China, major geological features of tight oil are identified and major parameters for the evaluation for “sweet area” are proposed. These can provide important reference for continuously promoting the exploration for this important

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unconventional oil. “Sweet area” refers to the target area rich in unconventional tight oil which should be developed in priority under current economic and technical conditions.

2 Global tight oil exploration and development

Tight oil has become a new focus, after shale gas, in exploration and development of unconventional oil and gas around the world. The U.S. Energy Information Administration (EIA) predicted that the technically recoverable tight oil (shale oil) resources of 42 countries had reached 473×10^8 t in 2013, revealing great resource potential. At present, the exploration and development of tight oil are concentrated in North America and China. North America has achieved intensive exploration and development, while China is in the early stage of industrial exploration.

The US has repeated the shale gas success in the exploration and development of tight oil. Nearly 20 tight oil basins have so far been discovered, including Williston, Gulf Coast, and Fort Worth, with multiple producing zones like Bakken, Eagle Ford, Barnett, Woodford, and Marcellus-Utica (Schmoker 2002; Jarvie et al. 2007, 2010; Cander 2012; Corbett 2010; Camp 2011; EIA 2012, 2013; Lu et al. 2015). Since 2008, these discoveries have reversed the previous oil production decline in the US. On the whole, the marine tight oil of North America is predominantly distributed in three sets of shale formations, i.e., Devonian, Carboniferous, and Cretaceous, and occasionally in Cambrian, Ordovician, Permian, Jurassic, and Miocene. The US tight oil production amounted to 2.09×10^8 t by 2014, accounting for 36.2 % of total US oil production. EIA predicted in 2013 that the technically recoverable tight oil resources of the US would be 79.3×10^8 t, revealing good prospects for tight oil exploration and development. In addition to the US, tight oil has also been discovered in Canada, Argentina, Ecuador, the UK, Russia, etc.

In China, tight oil is extensively distributed in the continental strata of major oil and gas basins, as widely distributed tight sandstone oil or tight carbonate oil associated or in contact with lacustrine source rocks (Sun et al. 2011; Li et al. 2011; Li and Zhang 2011; Jia et al. 2012a, b; Kang 2012; Ma et al. 2012; Zhang 2012; Zou et al. 2012, 2013a, b, c; Guo et al. 2013). In recent years, strategic breakthroughs have been successively achieved in the Ordos and Songliao Basins (Yang et al. 2013; Yao et al. 2013; Huang et al. 2013; Zou et al. 2012, 2013a, b, c, 2015). By the end of 2013, total proven technically recoverable reserves of tight oil were 3.7×10^8 t in the Ordos, Songliao, Junggar, Bohai Bay, and Sichuan and Qaidam Basins (Liang et al. 2011; Kuang et al. 2012; Zhang et al. 2012; Liang et al. 2012; Song et al. 2013; Yang et al. 2013; Huang et al.

2013; Yao et al. 2013; Fu et al. 2013). Currently, the Chang7 oil layer in the Ordos Basin and the Fuyang oil layer in the Songliao Basin have been developed on a large scale. PetroChina Changqing Oilfield Company has developed the first 100-million-ton tight oil field—Xin’anbian Oilfield, making Changqing Oilfield form a capacity of 1 million tons per annum. With this discovery, which is a milestone in China’s oil history, in 2014 tight oil was integrated officially into the category for reserves evaluation. At present, China is undertaking an in-depth study of technologies to evaluate tight oil “sweet area” and building test regions. Once breakthroughs are made in key technologies and more efforts are made in this aspect, the development and utilization of tight oil will be further accelerated.

3 Geological features of tight oil

The tight oil fields of North America and China have two essential features. Firstly, oil is extensively distributed, without clear trap boundaries. Secondly, there is no natural industrial oil production with unobvious Darcy flow (Zeng et al. 2010; Nelson 2009, 2011; Zou et al. 2012, 2013a, b, c; Chen et al. 2013; Gaswirth and Marra 2015; Peters et al. 2015; Li et al. 2015; Pang et al. 2015; Sun et al. 2014; Yuan et al. 2015; Wu et al. 2015; Li et al. 2015). Taking the continental tight oil of China as example, it has four typical geological features (Zou et al. 2012, 2013a, b, c) (Table 1; Fig. 1).

1. It is generally well preserved and distributed in depressions and slopes, where the structure is stable. In China, tight oil is predominantly distributed in depression and slope belts. For example, in the Ordos Basin, tight oil is distributed in the sandy debris flow and delta front sandbodies in the basin center; in the Junggar Basin, tight oil is distributed in the carbonate and hybrid sedimentary reservoirs in the depression center; in the Songliao Basin, tight oil is distributed in the delta front sandbodies in basin slope–depression locations.
2. Large-scale mature high-quality source rocks are extensively developed. In China, continental source rocks are frequently present in Mesozoic and Cenozoic strata of rift, depression, and foreland basins. Their TOC is in a wide range, generally 2 %–15 %, and the thermal evolution degree R_o is low, generally 0.6 %–1.0 %. Organic-rich shale is extensive in depression centers and slopes.
3. Tight oil reservoir space consists of micro- and nanopore throat systems, with poor physical properties. In China, continental tight oil reservoirs are

Table 1 Parameters of typical marine and continental tight oil reservoirs

Item	Evaluation parameters	Bakken	Eagle Ford	Lucaogou Formation, Junggar Basin	Chang7 Member, Ordos Basin
Source–reservoir assemblage	Contact area, km ²	>30,000	>30,000	2000	20,000
Source condition	TOC, %	11–>20	3–7	3–16	4–20
	Type of parent material	Type II	Type II	Type II	Type I, II ₁
	R _o , %	0.7–1.0	0.5–1.5	0.6–0.9	0.7–1.1
	Thickness of source rocks, m	6.7	20–30	50–70	20–40
	Distribution area, km ²	58,000	52,000	1500	20,000
Reservoir condition	Petrology	Fine sandstone, dolomitic sandstone, dolomite	Marl	Dolomitic sandstone, dolomite	Silty-fine sandstone
	Reservoir space type	Fracture-pore type	Fracture-pore type	Fracture-pore type	Pore type
	Reservoir connection	Well connected	Well connected	Well connected	Well connected
	Porosity, %	5–12, 8 on average	5–12, 9 on average	6–16, 10 on average	7–14, 10 on average
	Mineral composition	Quartz + feldspar 40 %–60 %, carbonates 20 %–25 %, clay minerals 15 %–20 %	Quartz + feldspar 20 %–30 %, carbonates 50 %–70 %, clay minerals <10 %	Quartz + feldspar 20 %–50 %, carbonates 40 %–70 %, clay minerals <10 %	Quartz + feldspar 65 %–85 %, debris 15 %–35 %
	Buried depth, m	1370–2300	1300–3500	3000–4000	1900–2300
	Reservoir thickness, m	>30	30–90	25–35	20–30
	Distribution area, km ²	>40,000	>40,000	>5000	>30,000
Tectonic setting	Basin type	Craton basin	Craton basin	Depression basin	Craton basin
	Depositional environment	Marine facies	Marine facies	Continental facies	Continental facies
	Tectonic movement	Stable	Stable	Stable	Stable
	Formation pressure gradient, MPa/100 m	1.3–1.5	1.3–1.8	1.1–1.3	0.7–0.85
Transformative property	Natural fracture	Developed	Developed	Developed	Developed
Fluid condition	Poisson's ratio	0.22–0.29	0.24–0.26	0.23	0.21
	API	41–48	40–70	24–30	37–40
	Gas/oil ratio	500–1800	800–2000	~ 50	118
	Number of producing wells	Over 5000 wells	Over 5000 wells	20 wells	200 wells
	Individual well production, t/d	70	20–100	2–30	3–30
	Individual well cumulative production, 10 ⁴ t	3–10	3–10	2–4 (predicted)	2–4 (predicted)

Table 1 continued

Item	Evaluation parameters	Bakken	Eagle Ford	Lucaogou Formation, Junggar Basin	Chang7 Member, Ordos Basin
	Current annual production, t	Over 60 million	66 million	3	70

Fig. 1 Tight oil distribution of the Yanchang Formation, Ordos Basin

characterized by strong heterogeneity, rapid lateral variation, low porosity (5 %–12 %), and low matrix permeability, predominantly with micro- and nanopore throats.

- Source rocks and reservoirs are in close contact. Tight oil with extensive distribution is accumulated near source rocks in a non-buoyant manner, with “sweet spots” present locally. In all major oil basins of China, tight oil is distributed close to source rocks in a large area and with large resource potential. For example, in the Ordos Basin, the contact area between the producing layer of the middle-upper Chang7 Member and the shale of the lower Chang7 Member is more than $5 \times 10^4 \text{ km}^2$; in the Junggar Basin, the contact area between the tight oil of the Lucaogou and Fengcheng Formations and high-quality source rocks is large in depression center; in the Songliao Basin, the contact area between the Fuyang tight oil layer and underlying

source rocks of the Qingshankou Formation is more than $3 \times 10^4 \text{ km}^2$.

Compared with marine tight oil of the United States, continental tight oil of China is complex and special (Fig. 2) with six prominent features. First, its source rocks have a low degree of thermal evolution R_o (0.6 %–1.0 %). Second, reservoir porosity changes slightly (5 %–12 %). Third, oil saturation changes significantly (50 %–90 %). Fourth, reservoir fluid pressure changes significantly (both overpressure and negative pressure). Fifth, it is heavy oil with low gas/oil ratio. Sixth, the cumulative production of individual wells is low, generally 2×10^4 – $5 \times 10^4 \text{ t}$. Its development and testing time are limited since it is still under pilot test phase at present. The individual well stable production of general horizontal segment after fracturing is 10–30 t/d. Industrial-scale development of continental tight oil in China faces great theoretical and technological challenges.

Fig. 2 Tight oil distribution in major oil/gas-bearing basins in North America and China

4 Tight oil “sweet area” evaluation

4.1 Parameters and criteria

A tight oil “sweet area” refers to an area rich in unconventional oil and gas, where test production and initial production of individual wells will both be high, thus its exploration and development can be conducted as a priority under current economic and technical conditions. Tight oil “sweet area” generally occur in the area where source rocks and reservoirs are associated and natural fractures and localized structures are present. “Sweet area” are characterized by wide distribution, large thickness, high-quality source rocks, relatively good reservoir physical properties, high oil and gas saturation, light oil, high formation energy (high gas/oil ratio, high formation pressure), and high brittleness index (Fig. 3). It should be noted that under current economic and technological conditions both domestic and overseas, a definite structural setting (which is favorable for long-term oil and gas accumulation and favorable for the development of natural fractures) and good fluidity are the prerequisite for the formation of tight oil “sweet area.” For example, the Cretaceous Eagle Ford tight oil formation in Southwest Texas, US, has high-yield “sweet area” with good oil quality, high gas/oil ratio, and high formation pressure. These are concentrated in the inherited paleohigh crest and southwestern flanks, where natural fractures are frequently present.

Evaluating and selecting “sweet area” is the focus for unconventional tight oil research, which is being conducted throughout the entire exploration and development process. Unconventional tight oil sweet spots include geological,

engineering, and economic sweet spots (Zou et al. 2012, 2013a, b, c). The evaluation should focus on relationships between “six features,” namely source properties, lithology, physical properties, brittleness, hydrocarbon potential, and stress anisotropy, to evaluate source rock quality, reservoir quality, and engineering quality and determine the distribution scope of tight oil “sweet area.” Eight evaluation indexes for tight oil “sweet area” are proposed, among which high TOC value, high porosity, and the development of micro-fractures are major controlling factors. Comprehensive evaluation should focus on source rock, reservoir, overpressure, and fracture for geological “sweet area,” on buried depth, rock compressibility, and stress anisotropy for engineering “sweet area,” and on resources scale, buried depth and surface conditions for economic “sweet area.” At present, priority should be given to favorable source rock, reservoir, overpressure, fracture, and local structure of geological “sweet area,” and pressure coefficient, brittleness, crustal stress, and buried depth of engineering “sweet area” (Table 2).

According to the evaluation criteria of tight oil source rocks and reservoirs (Table 3), tight oil “sweet area.” in China were evaluated. Areas with grade I and II source rocks and reservoirs are tight oil “sweet area.” Finally, 20 favorable “sweet area” with an area of 5100 km² and resources of 45×10^8 t were identified in the Songliao, Ordos, and Junggar Basins. Based on the evaluation results, the tight oil “sweet area” of the Fuyu oil layer in the Songliao Basin have an area of 1.5×10^4 km² and resources of 25×10^8 t (Fig. 4); the tight oil “sweet area” of the Chang7₁ Member in the Ordos Basin have an area of 3.5×10^4 km² and resources of 14×10^8 t (Fig. 4); the tight oil “upper sweet section” of the Lucaogou Formation in the Jimsar Sag of the Junggar Basin have an area of 260 km² and resources of 2.5×10^8 t.

In China, tight oil is pervasive and diversified. It is predominantly tight sandstone oil and tight carbonate oil in contact with or associated with lacustrine source rocks. As estimated, major onshore tight oil basins in China have an area of 50×10^4 km², geological resources of about 200×10^8 t, and technically recoverable resources of $(20\text{--}25) \times 10^8$ t. The preliminarily proven technically recoverable reserves of tight oil are nearly 3.7×10^8 t in the tight sandstone of Cretaceous Qingshankou–Quantou Formation of the Songliao Basin, the tight sandstone of Triassic Chang7 Member of the Ordos Basin, the argillaceous dolomite of Permian Lucaogou Formation of the Junggar Basin, the Middle-Lower Jurassic tight limestone of the Sichuan Basin, the marl and tight sandstone of the Shahejie Formation of Bohai Bay Basin, the Cenozoic marl and tight sandstone of the Qaidam Basin, and the Cretaceous marl of the Jiuquan Basin.

Fig. 3 Mineral composition of oil-bearing tight reservoirs of the Eagle Ford and the Lucaogou Formation in the Junggar Basin

Table 2 Evaluation criteria for tight oil “sweet spots”

Oil and gas types	Geological “sweet area”			Engineering “sweet area”				
	Source rock	Reservoir	Fracture	Local structure	Formation pressure gradient, MPa/100 m	Oil saturation, %	Brittleness index, %	Horizontal principal stress difference, MPa
Tight oil of North America								
Eagle Ford liquid hydrocarbon of west of the Gulf of Mexico	TOC is >4 %	Porosity>7 %	Micro-fractures are developed	Relatively high position	>1.3	>60	>50	<10
Bakken tight oil of the Williston Basin	Thickness is 20–60 m, TOC value is 4 %–8 %, R_o value is 0.9 %–1.5 %	Thickness is 10–30 m, porosity is 7 %–14 %, oil saturation is greater than 70 %	Micro-fractures are developed	Paleohigh crest and slope	>1.4	>60	>50	<10
	Thickness is >5 m, TOC value is >8 %, R_o value is >0.7 %	Thickness is 5–20 m, porosity is 7 %–12 %, oil saturation is greater than 70 %	Micro-fractures are developed	Relatively high position	>1.35	>60	>50	<10
								1500–3500
Tight oil of China								
Evaluation criteria	TOC >2 %	Porosity >8 %	Micro-fractures are developed	Relatively high position	>1	>60	>40	<6
								<4500
Tight oil of the Chang7 member, in the Ordos Basin								
	Thickness is 10–30 m, TOC value is 3 %–25 %, R_o value is 0.8 %–1.2 %, S_1 value is 1–8 mg/g	Thickness is 20–30 m, porosity is 10 %–15 %, oil saturation is greater than 60 %	Micro-fractures are developed	Relatively high position in slope	0.7–0.8	>70	>50	<10
								1000–3000
Tight oil of the Lucaogou Formation in Jimsar Sag, Junggar Basin								
	Thickness is 100–130 m, TOC value is 5 %–6 %, R_o value is 0.8 %–1.0 %	Thickness is 25–50 m, porosity is 12 %–20 %, oil saturation is greater than 70 %	Micro-fractures are developed	Relatively high position in slope	1.2–1.5	>90	>50	<6
								1000–4500

Table 3 Comprehensive evaluation of continental tight oil in China by source rocks and reservoirs

Item		Grade I	Grade II	Grade III
Source rocks	TOC, %	>2	1–2	<1
	$S_1 + S_2$, mg/g	>6	2–6	<2
	Organic matter type	I–II ₁	II ₁ –II ₂	II ₂ –III
	Maturity R_o , %	0.9–1.3	0.7–0.9	0.4–0.7
Reservoirs	Porosity, %	>8	5–8	<5
	Permeability, mD	>0.2	0.04–0.2	<0.04
	Oil saturation, %	>60	40–60	20–40
	Throat radius, mm	>0.15	0.05–0.15	0.01–0.05
	Thickness, m	>10	5–10	<5
	Brittleness index, %	>50	40–50	30–40

Fig. 4 Tight oil “sweet area” in China’s major oil and gas basins. **a** Tight oil “sweet area” distribution of the Fuyu oil layer, Songliao Basin; **b** tight oil “sweet area” distribution of Chang 7₁ Member in the Ordos Basin

4.2 Case study

The Bakken tight oil region is located in the Williston Basin, crossing the United States and Canadian border, with an oil-bearing area of 7×10^4 km² (Fig. 5) (Sarg, 2012). The Upper Devonian–Lower Carboniferous strata can be divided into nine lithological units, with individual layer thicknesses of 5–15 m, cumulative thickness of 55 m, and buried depth of 2590–3200 m. They were deposited under offshore shelf–lower shoreface environments and are composed of dolomitic siltstone, bioclastic sandstone, and

calcareous siltstone, with porosities of 2 %–9 % and an average permeability of 0.05 mD. Two sets of shale are present in the Bakken Formation, predominantly distributed in the northern-central basin, with thicknesses of 5–12 m, TOC of 10 %–14 %, and R_o of 0.6 %–0.9 %, and their recoverable resources are 68×10^8 t predicted by HIS. As of 2010, a total of 2362 tight oil wells were in production in the Bakken region of the US, with an average daily oil production of 12 t, with a maximum of 680 t. The crude oil density is 0.78–0.85 g/cm³, which is light, the pressure coefficient is 1.15–1.84, gas/oil ratio is 53–160,

Fig. 5 Lithology and oil layer distribution of Bakken tight oil in the Williston Basin

and the annual oil production is greater than 5000×10^4 t. The tight reservoirs of the Bakken Member are bounded above and below by the source rocks of the Bakken, forming a good source–reservoir assemblage. The “sweet spots” are mainly controlled by the regional and local fracture systems arising from the tectonic background, and the superimposed areas of both organic-rich shales and thick dolomitic pore-type reservoirs.

The Eagle Ford tight oil region trending SW–NE is located in the Gulf Coast Basin, southern Texas. It is 440 km long and 80 km wide, with an area of 3×10^4 km². The tectonic setting of Eagle Ford is an NW–SE dipping slope, including three types of hydrocarbon maturity windows, i.e., crude oil, condensate oil–wet gas, and dry gas. Its formation thickness ranges from a few meters to more than one hundred meters (Li et al. 2011; Kevin 2010). Eagle Ford can be divided into upper and lower intervals, among which the lower interval, located between upper Austin limestone and lower Buda limestone, is the major target zone for oil and gas at present. So far, the exploration of Eagle Ford is focused on the liquid hydrocarbon-rich zone with high economic value. The

maturity of source rocks ranges between 0.9 % and 1.5 %. The target zone is in the lower shale interval which is rich in organic matter. As of 2014, the daily tight oil production has exceeded 1×10^6 bbl/d. The distribution of the “sweet area” in the lower Eagle Ford major producing interval is predominantly under the control of maturity, formation thickness, API, gas/oil ratio, pressure coefficient, natural fracture, TOC, porosity, oil saturation, and other parameters. The developed area of “sweet area” generally has a high formation thickness (greater than 20 m) and TOC (greater than 4 %) value, high brittle mineral content (greater than 90 %), light oil (API of greater than 35°), high fluid pressure (pressure coefficient between 1.3 and 1.8), and gas/oil ratio (greater than 5000 scf/bbl), where natural fractures are extensive.

The “six features” evaluation parameters of the tight oil “sweet area” of the Lucaogou Formation in the Jimsar Sag are shown in Fig. 6. Source rocks are of high quality, with an average TOC of 5 %–6 %, R_o of 0.8 %–1.1 %, and type II kerogen. The reservoirs, composed of dolomitic sandstone, are also of high quality and have good physical properties, with a porosity of 6 %–20 % and a permeability

Fig. 6 Typical individual well comprehensive evaluation histogram of the Jimsar Sag, Junggar Basin

of generally lower than $1 \times 10^{-3} \mu\text{m}^2$, where matrix pores are frequently present, with well-connected micro-fine pores dominating. Oil potential is good, with oil saturation of generally greater than 70 % and crude density of 0.88–0.92 g/cm³ without water cut. Reservoirs have a high brittle mineral content, with a brittleness index >60 %, elastic modulus $>1.0 \times 10^4$ MPa, and Poisson's ratio <0.35. The horizontal stress difference is small, generally less than 6 MPa, which is beneficial for volume fracturing. The oil-bearing properties of the tight reservoirs which are in the upper and lower members of the Lucaogou Formation in the Jimsar Sag are more closely related to the maturity of adjacent source rocks than reservoir porosity. The maturity of the shale in the lower member is higher than that of the shale in the upper member, and thus the tight oil/shale oil potential of the lower member of the Lucaogou Formation is significantly better than that of the upper member, since the tight oil/shale oil saturation of the lower member reaches over 90 %, basically without water cut. The major constraints of tight oil are low maturity, heavy oil quality, low gas content, low formation pressure, and poor fluid mobility as well as difficulty in exploiting and producing.

The Mesozoic Chang7 tight oil in the Ordos Basin is distributed in 11 enrichment regions, with an area of 3×10^4 km² and reserves of greater than 20×10^8 t. The Chang7 marl has a high abundance of organic matter, TOC value of 5 %–8 %, type I–II₁ kerogen, R_o of 0.7 %–1.2 %, and pyrolysis T_{max} of 435–455 °C (Fig. 7). Its tight reservoirs are predominantly composed of lithic feldspathic sandstone with primary and secondary pores. Reservoir physical properties are good, with a porosity of 7 %–13 %. The oil-bearing properties are good, with oil saturation of 60 %–80 %; brittle minerals are common, with a brittleness index of 35 %–45 %, and the horizontal stress difference is 5–7 MPa. The Chang7 tight oil is advantaged by light oil quality, high gas/oil ratio, good reservoir compressibility, extensive micro-fractures, and low water cut; however, its major constraint is low formation pressure.

5 Conclusions

Tight oil is an important type of unconventional oil resource. It is extensive in global oil and gas basins, especially in North America and China. In North America,

Fig. 7 Typical individual well-integrated histogram of the Triassic Chang7 Member, Ordos Basin

marine tight oil is intensively explored. In China, commercial tests are being steadily conducted for continental tight oil. Geologically, tight oil is characterized by distribution in depressions and slopes of basins, extensive, mature, and high-quality source rocks, large-scale reservoir space with micro- and nanopore throat systems, closely contacted source rocks and reservoirs with continuous distribution, and local “sweet area.” The evaluation of the distribution of tight oil “sweet area” should focus on relationships between “six features,” including source properties, lithology, physical properties, brittleness, hydrocarbon potential, and stress anisotropy. Continental tight oil is extensive in China, with preliminarily estimated technically recoverable oil resources of about $(20\text{--}25) \times 10^8$ t.

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