Characteristics, Accumulation Conditions, and Exploration Prospects of Tight Oil in China

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General Comments

Characteristics of China’s Tight Oil
- Coexisting source and reservoir, indistinct trap boundaries, extensively distributed in good source rocks.
- Continuous and non-buoyancy accumulation, typically short-distance migration.
- Poor properties: matrix permeability ≤ 0.1 md, porosity ≤ 10%.
- Nano-level pore-throat system developed, diameters typically between 40 and 900 nanometers.
- Major types: lacustrine carbonates, deep gravity quickstone and submerged delta.
- Relatively high pressure coefficient, relatively low crude density
- Rapid production decline, long production cycle, maintaining production by new well drilling

Major Differences between China and US Tight Oil
- North America: Typically marine deposit, widely distributed
- China: Typically nonmarine deposit, heterogeneity
- North America: Better porosity and permeability
- North America: More condensate oil
- North America: Ro: around 1.3%, lighter than that of China

Tight Oil: Major Unconventional Oil/Gas Exploration Targets in China

Reference

Zou, Caineng, 2011, Unconventional petroleum geology: Beijing, China, 310 p.
Characteristics, Accumulation Conditions, & Exploration Prospects of Tight Oil in China

ZOU Caineng

Research Institute of Petroleum Exploration & Development (RIPED)
Singapore, March, 2012
1. Current Status & Definition of Tight Oil
2. Characteristics of China’s Tight Oil
3. Exploration Potentials of Tight Oil in China
1. Current Status & Definition

Rapid Development of Tight Oil E&D in USA

Source: IHS

- Recoverable Resources: 6,800 MMT
- 2010 Production: 30 MMT
- 2020 Production: 150 MMT

(Source: IHS, 2011)
Tight Oil: A New Drive for US Oil/Gas Industry

Condensate Oil Production

Tight Oil Production

(PFC, 2011)
Definition of Tight Oil

Tight Oil:

- Petroleum Collects in Source Rock or in the closely related Tight Sands or Tight Carbonates
- Permeability typically $\leq 0.1\text{mD}$
- Indistinct Trap Boundaries
- Difference from Shale Oil, Oil Shale, Fractured Shale Oil in Accumulation & Distribution, Production Techniques
Definition of Tight Oil

Typically short-distance migration & accumulation, no distinct trap boundaries

Collects in source rock or in closely related tight sands or tight carbonates

Migration & Accumulation Mode of Tight Oil

Depth (KM)

Oil Shale

Tight Limestone

Shale Oil

Tight Sandstone

Shale Oil

Ro (%)
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2. Characteristics of China’s Tight Oil

1. Coexisting Source and Reservoir, Indistinct Trap Boundaries, Extensively Distributed in Good Source Rocks.

2. Continuous & Non-buoyancy Accumulation, Typically Short-distance Migration.

3. Poor Properties: Matrix Permeability $\leq 0.1\text{mD}$, Porosity $\leq 10\%$.


5. 3 Major Types: Lacustrine Carbonates, Deep Gravity Quickstone and Submerged Delta.

6. Relatively High Pressure Coefficient, Relatively Low Crude Density

7. Rapid Production Decline, Long Production Cycle, Maintaining Production by New Well Drilling
2. Characteristics of China’s Tight Oil

- Coexisting Source and Reservoir, Indistinct Trap Boundaries, Extensively Distributed in Good Source Rocks

Accumulation Mode of Source-Reservoir Coexistence
Continuous & Non-buoyancy Accumulation, Typically Short-distance Migration.

Formation Temperature of Hydrocarbon Fluid Inclusion: 55~125°C:
CONTINUOUS OIL ACCUMULATION

Temperature Distribution of Fluid Inclusion,
Ordos Mesozoic Continuous Tight Oil Play
Porosity & Permeability of Major Tight Oil Formations, Lower-Middle Jurassic, Sichuan Basin

**Poor Properties:** Matrix Permeability ≤ 0.1 mD, Porosity ≤ 10%.

**Shell Limestone, Da’anzhai**
- \( \Phi \leq 1\% \)
- \( K < 0.1 \text{ mD} \)

**Lacustrine Sandstone, Lianggaoshan**
- \( \Phi \leq 2\% \)
- \( K < 0.1 \text{ mD} \)

**Lacustrine Sandstone, Lower Sha-1**
- \( \Phi \leq 5\% \)
- \( K < 1 \text{ mD} \)
Nano-level Pore-throat System Developed, Diameters typically between 40-900 NM

**Ordos Basin**
- Quartz Intragranular Pores, Gao 46 Well, Chang 6, 1742.5m

**Sichuan Basin**
- Calcite Intragranular Dissolved Pores, Pingchang 1, Da’anzhai, 3186.8m

**Illite Interlayer Pores**
- Xi 233 Well, Chang 72, 1968.15m

**Intercrystalline Micropores**
- Ren 1 Well, Da’anzhai, Grainstone
3 Major Types in Lacustrine Carbonates, Deep Gravity Quickstone and Submerged Delta.

Distribution of Conventional & Unconventional Accumulation Types

- Sand
- Shale
- Carbo.
- Metamo.
- Coal
- Volca.
- Oil
- Gas
- Oil/Gas
- Water
### High Pressure Coefficient and Low Crude Density

<table>
<thead>
<tr>
<th>Basins</th>
<th>Formation</th>
<th>Ro(%)</th>
<th>Pressure Coefficient</th>
<th>Crude Density (g/cm³)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Williston</td>
<td>Upper Devonian</td>
<td>0.6~1.0</td>
<td>1.35~1.58</td>
<td>0.81~0.83</td>
<td>Bakken</td>
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<tr>
<td>S. Texas</td>
<td>Cretaceous</td>
<td>0.5~2.0</td>
<td>1.35~1.80</td>
<td>0.82~0.87</td>
<td>Eagle Ford</td>
</tr>
<tr>
<td>Bohai Bay</td>
<td>Shahejie</td>
<td>0.5~2.0</td>
<td>1.30~1.80</td>
<td>0.67~0.85</td>
<td>Liaohe Sag</td>
</tr>
<tr>
<td>Bohai Bay</td>
<td>Shahejie</td>
<td>0.5~2.0</td>
<td>1.53~1.80</td>
<td>0.68~0.78</td>
<td>Jiyang Sag</td>
</tr>
<tr>
<td>Sichuan</td>
<td>Da’anzhai</td>
<td>0.5~1.6</td>
<td>1.23~1.72</td>
<td>0.76~0.87</td>
<td>Chuanzhong</td>
</tr>
<tr>
<td>Songliao</td>
<td>Qingshankou</td>
<td>0.5~2.0</td>
<td>1.20~1.58</td>
<td>0.78~0.87</td>
<td>Gulong Sag</td>
</tr>
<tr>
<td>Ordos</td>
<td>Yanchang</td>
<td>0.7~1.2</td>
<td>0.75~0.85</td>
<td>0.70~0.76</td>
<td>Yixia Slope</td>
</tr>
<tr>
<td>Qaidam</td>
<td>E System</td>
<td>0.5~0.8</td>
<td>1.47</td>
<td>0.72</td>
<td>Mangya Sag</td>
</tr>
</tbody>
</table>

**Pressure Coefficient: 1.2-1.8, Density: 0.7-0.9g/cm³**
Early Stage: Mainly via Fractures, Later Stage: Mainly via Pores

Fractures: Key to High Production

Luo 30 Well, Chuanzhong

Early Stage (1960-1962): Mainly via Fractures
Accum. Production: 7,687 tons

Later Stage (1963-present): Mainly via Pores
Accum. Production: 6,735 tons, 46.7% of total cumulative

(Source: Southwest Oil/gasfield, PetroChina)

Rapid Production Decline, Long Production Cycle, Maintaining Production by New Well Drilling
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Case 1: Yanchang Formation, Ordos Basin

- Source Rocks Developed in C-7 and C-9 Intervals
- Tight Oil May Be In the Lake Center
3. Exploration Potentials of Tight Oil in China

Major Differences between China & US Tight Oil

1. North America:
   Typically Marine Deposit, Widely Distributed

2. China:
   Typically Nonmarine Deposit, heterogeneity

2. Better Properties in North America
   Porosity and Permeability higher than that of China

3. More Condensate Oil in North America
   Ro: around 1.3%, Lighter than that of China

Tight Oil: Major Unconventional Oil/Gas
Exploration Targets in China
Thank You!

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