

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

Caineng Zou¹

Search and Discovery Article #80230 (2012)**

Posted June 18, 2012

*Adapted from oral presentation given in Singapore at the Geoscience Technology Workshop (GTW) on Unconventional Hydrocarbons, 15-16 March 2012

**AAPG©2012 Serial rights given by author. For all other rights contact author directly.

¹Research Institute of Petroleum Exploration & Development (RIPE), PetroChina Beijing (zcn@petrochina.com.cn)

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 $\leq 10\%$.
- 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.



PetroChina

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

ZOU Caineng

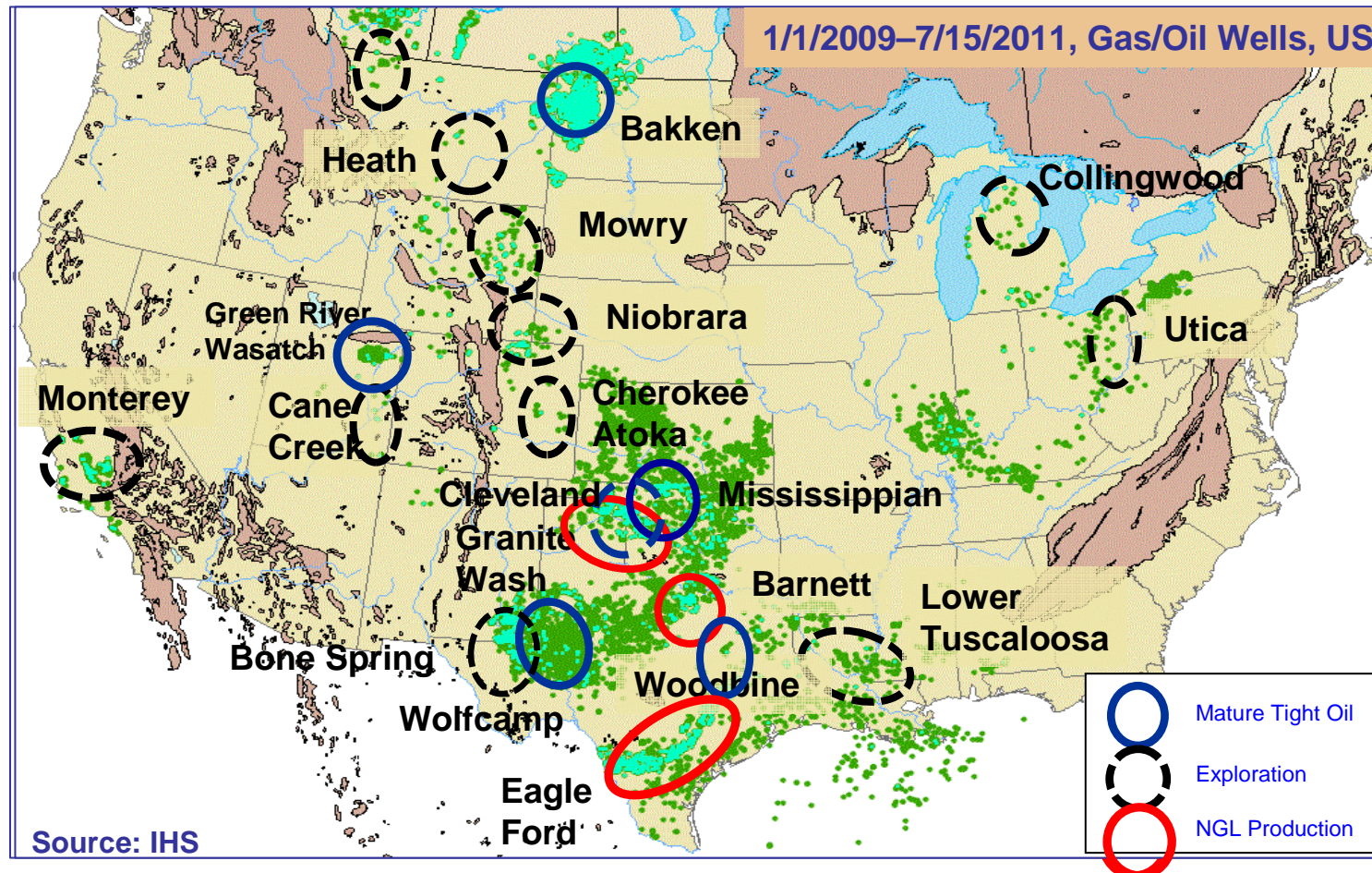
Research Institute of Petroleum Exploration & Development (RIPED)
Singapore, March, 2012

Table of Contents

- 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

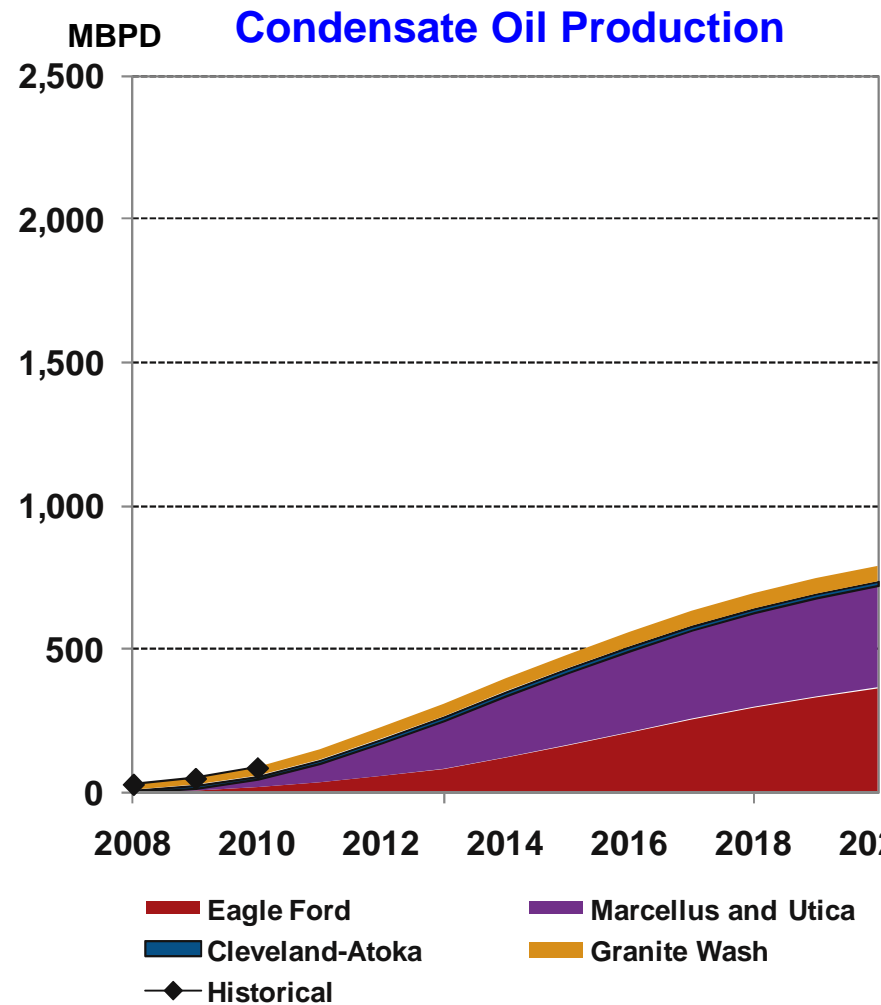
Rapid Development of Tight Oil E&D in USA



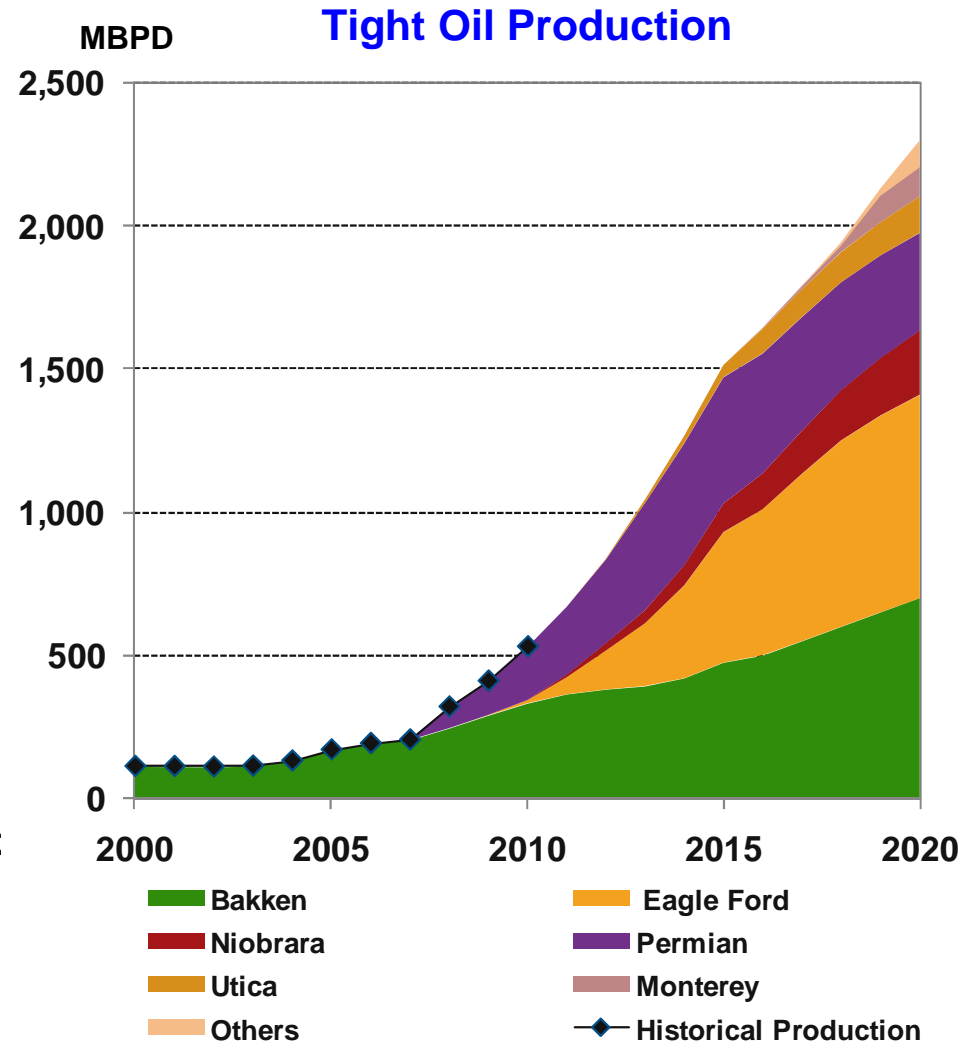
● Recoverable Resources: 6,800 MMT ● 2010 Production: 30 MMT ● 2020 Production: 150 MMT

(Source: IHS, 2011)

Tight Oil: A New Drive for US Oil/Gas Industry



(PFC, 2011)

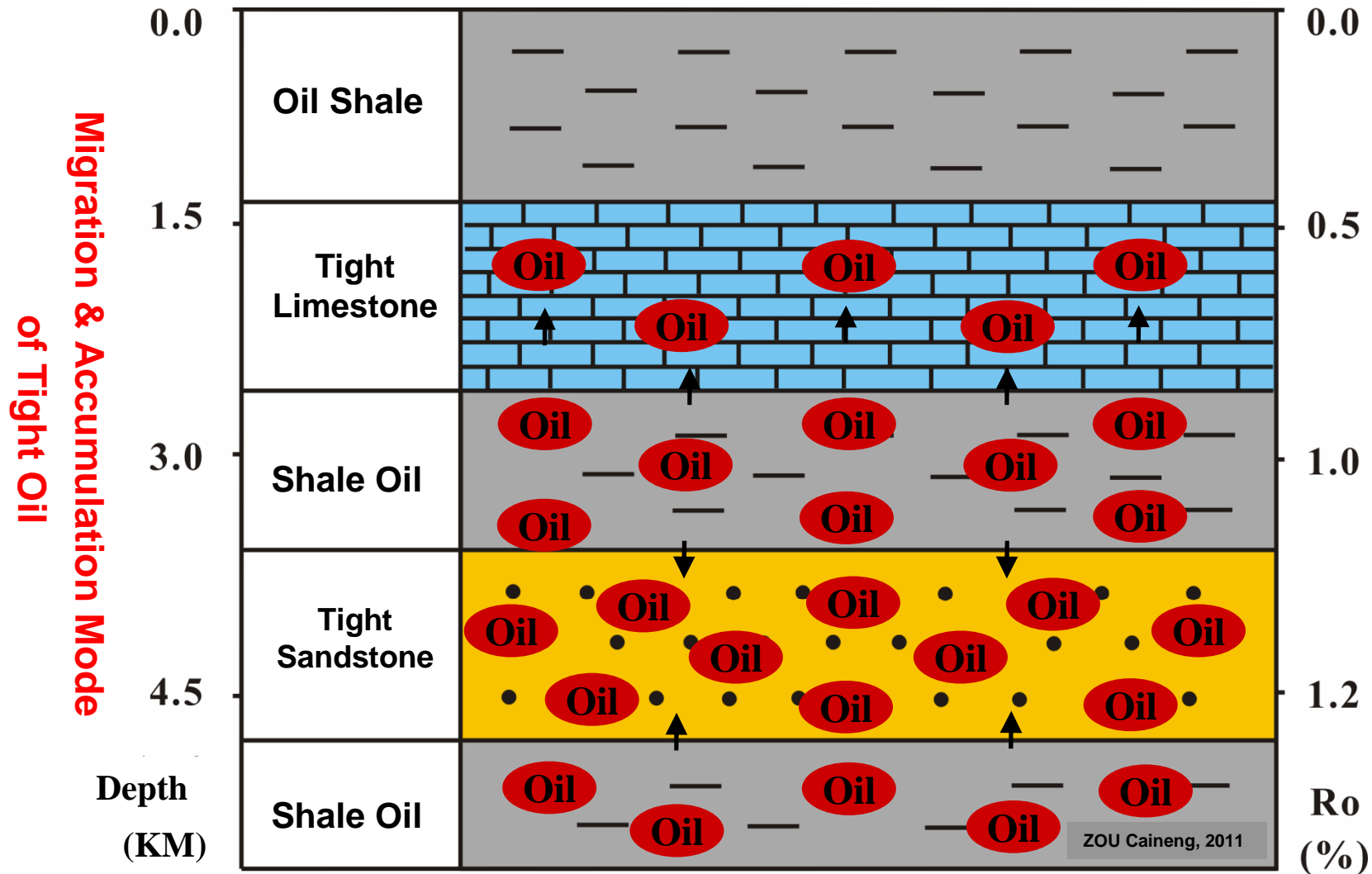


Definition of Tight Oil

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



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

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

Table of Contents

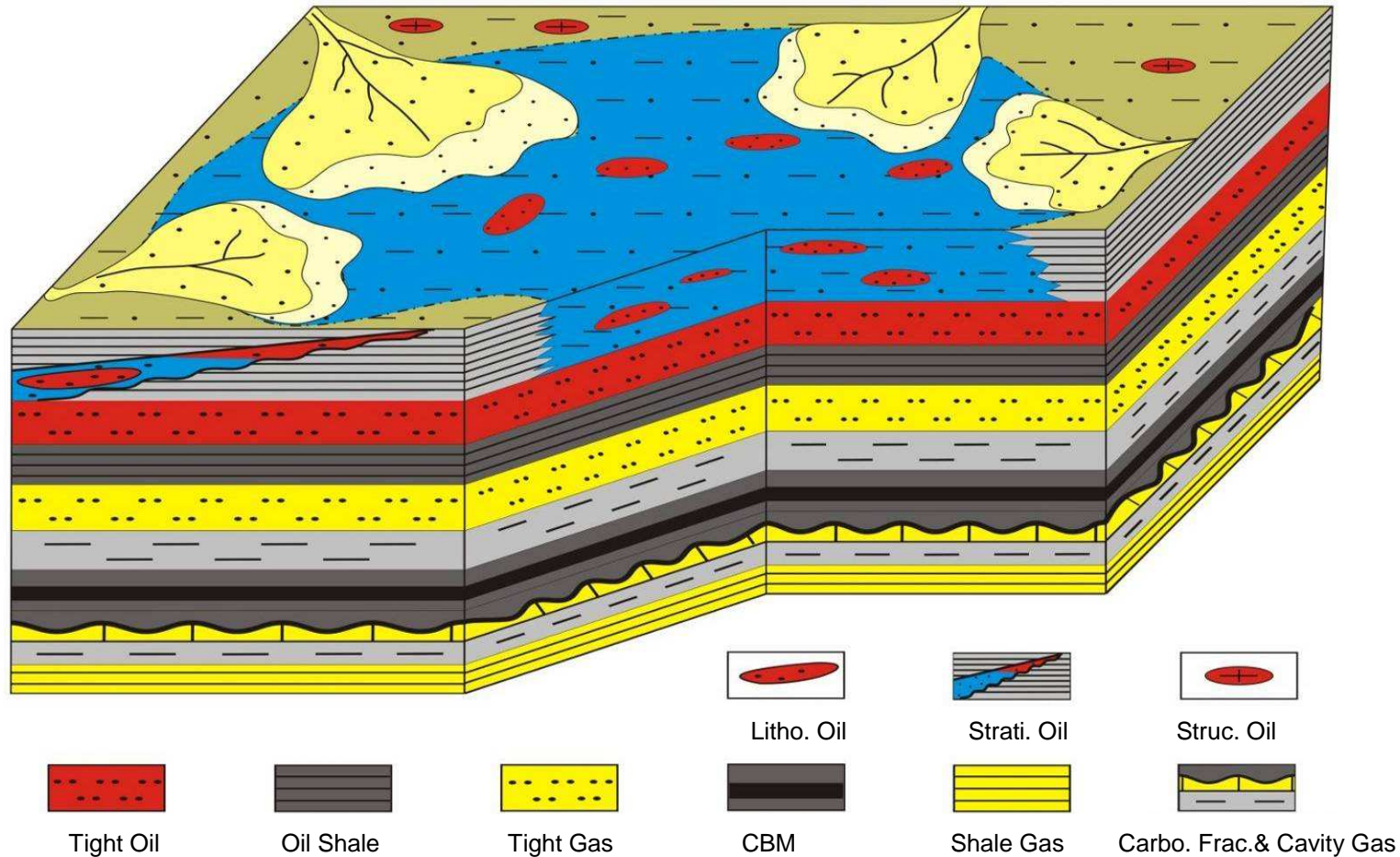
- 1. Current Status & Definition of Tight Oil**
- 2. Characteristics of China's Tight Oil**
- 3. Exploration Potentials of Tight Oil in China**

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 $\leq 10\%$.
- ④ Nano-level Pore-throat System developed, Diameters typically between 40 and 900 Nanometers.
- 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

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

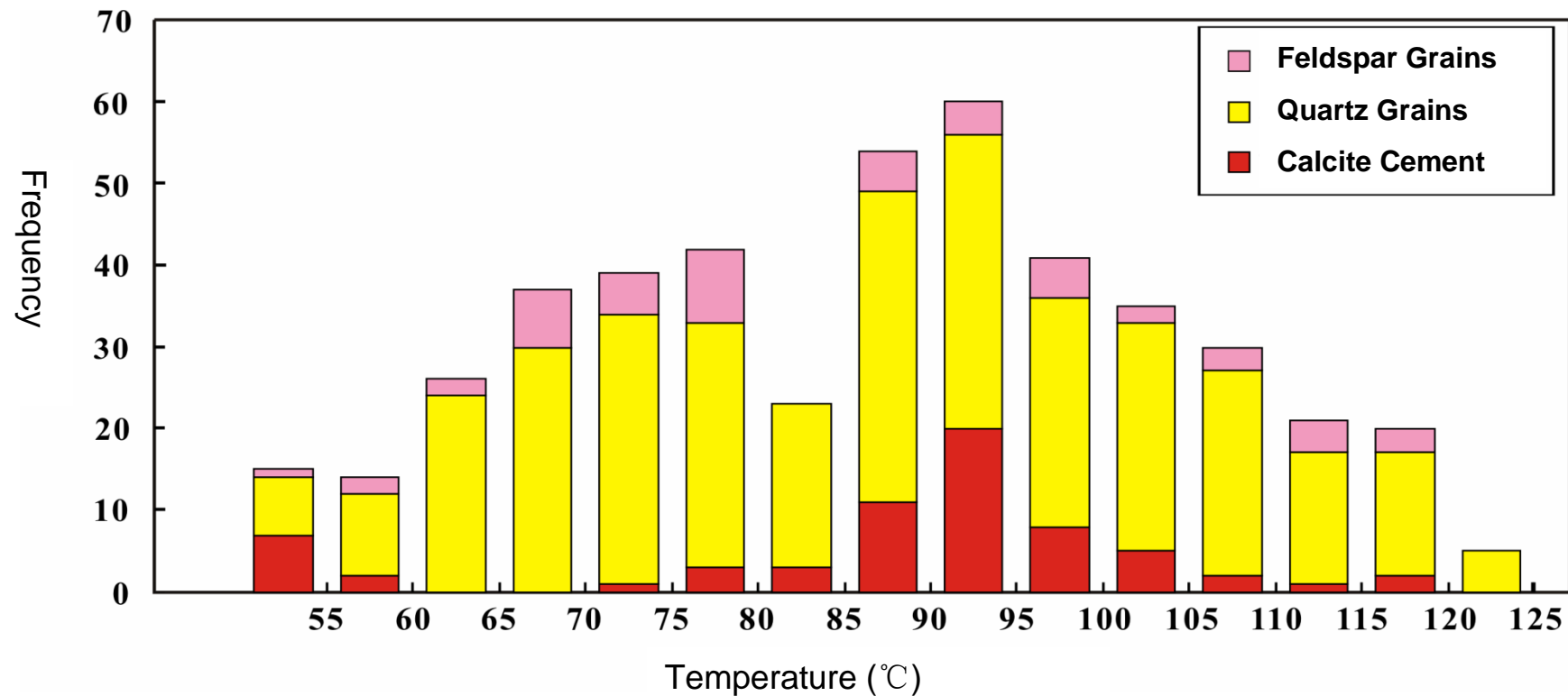


Accumulation Mode of Source-Reservoir Coexistence

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

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

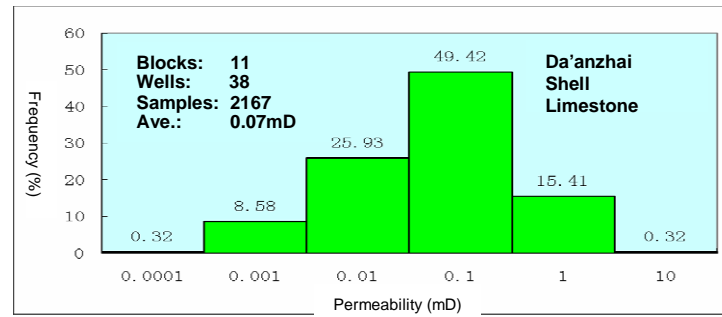
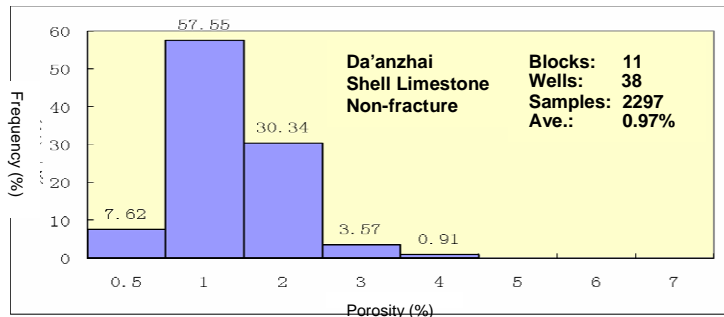
CONTINUOUS OIL ACCUMULATION



Temperature Distribution of Fluid Inclusion,
Ordos Mesozoic Continuous Tight Oil Play

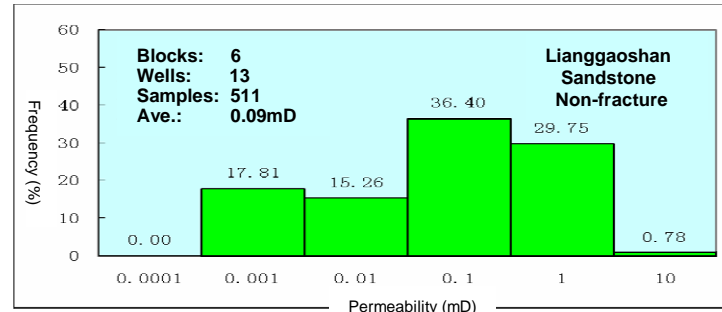
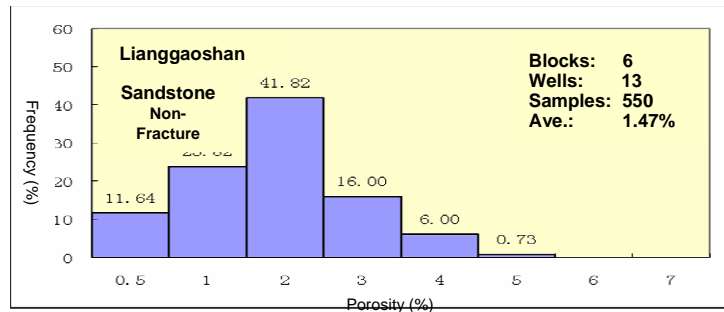
③ Poor Properties: Matrix Permeability ≤ 0.1 mD, Porosity $\leq 10\%$.

Porosity & Permeability of Major Tight Oil Formations, Lower-Middle Jurassic, Sichuan Basin



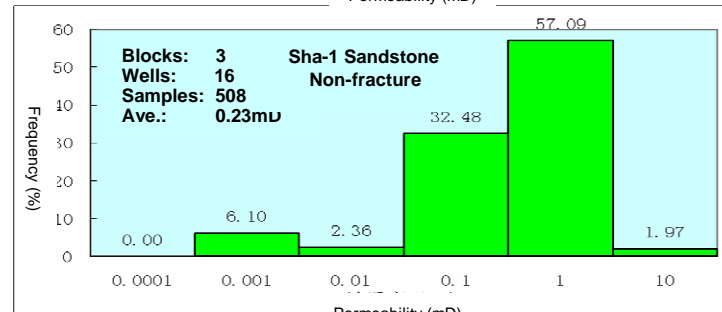
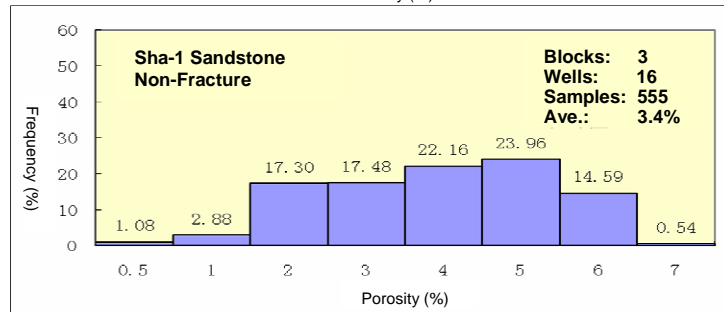
**Shell Limestone,
Da'anzhai**

$\Phi < 1\%$
 $K < 0.1$ mD



**Lacustrine
Sandstone,
Lianggaoshan**

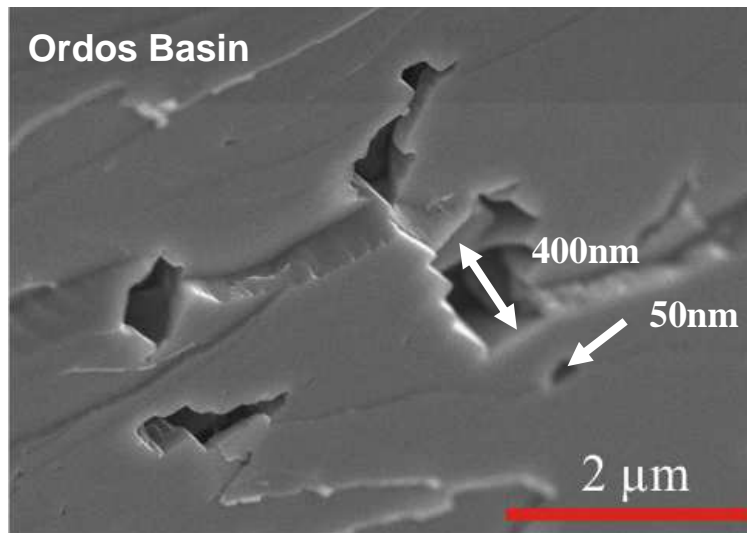
$\Phi < 2\%$
 $K < 0.1$ mD



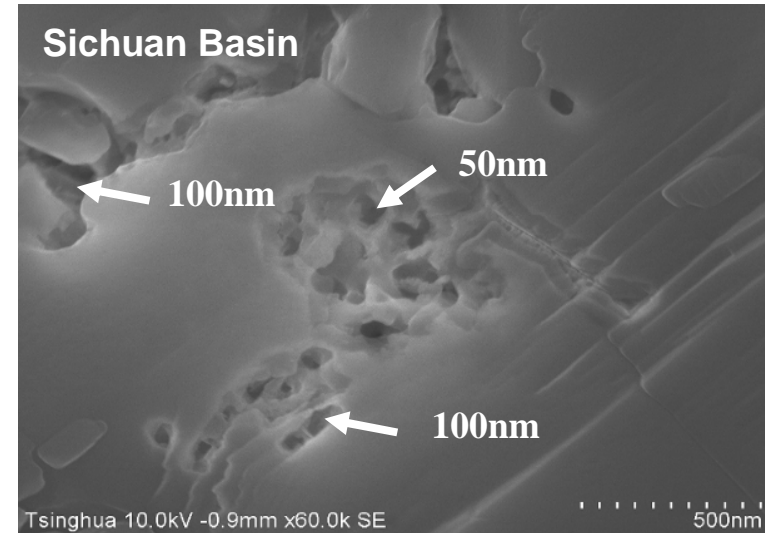
**Lacustrine
Sandstone,
Lower Sha-1**

$\Phi < 5\%$
 $K < 1$ mD

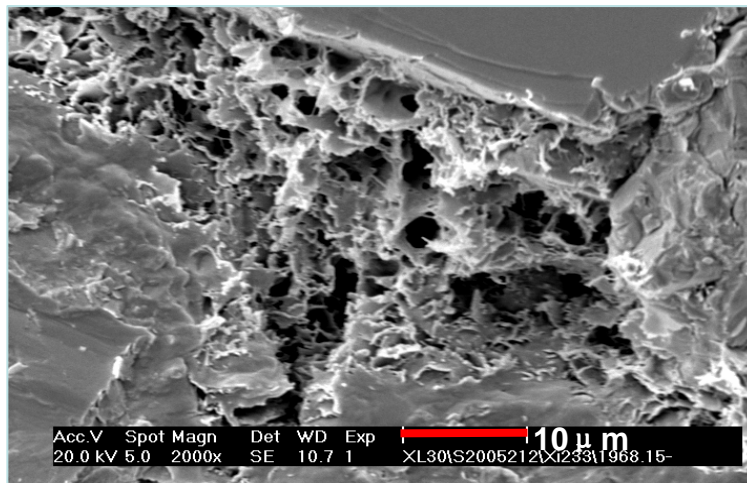
④ Nano-level Pore-throat System Developed, Diameters typically between 40-900 NM



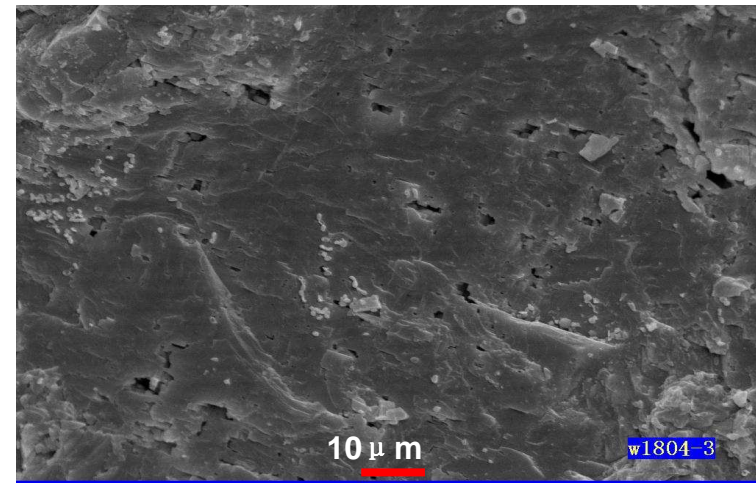
**Quartz Intragranular Pores,
Gao 46 Well, Chang 6, 1742.5m**



**Calcite Intragranular Dissolved Pores,
Pingchang 1, Da'anzhai, 3186.8m**

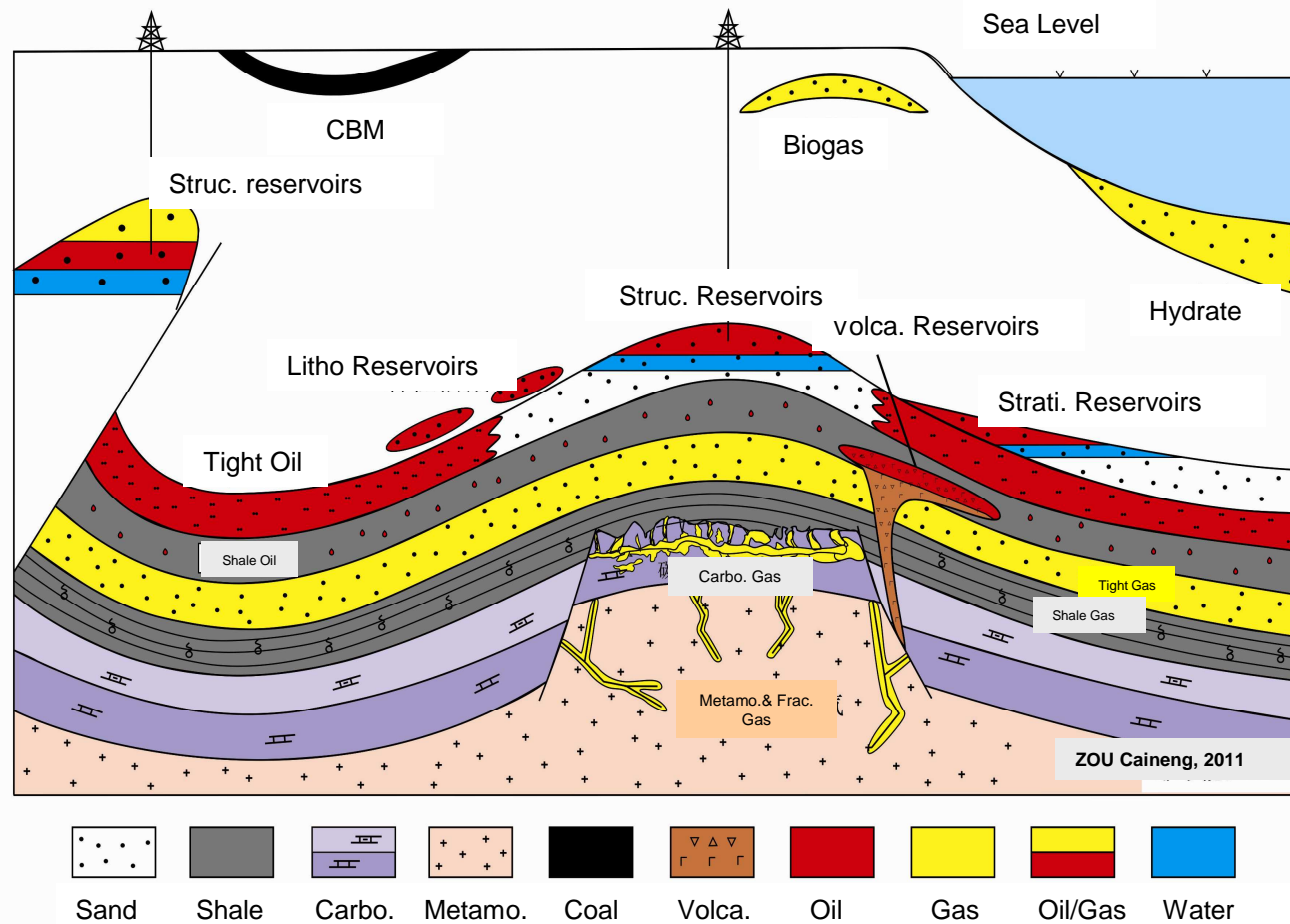


**Illite Interlayer Pores
Xi 233 Well, Chang 72, 1968.15m**



**Intercrystalline Micropores,
Ren 1 Well, Da'anzhai, Grainstone**

53 Major Types in Lacustrine Carbonates, Deep Gravity Quickstone and Submerged Delta.



Distribution of Conventional & Unconventional Accumulation Types

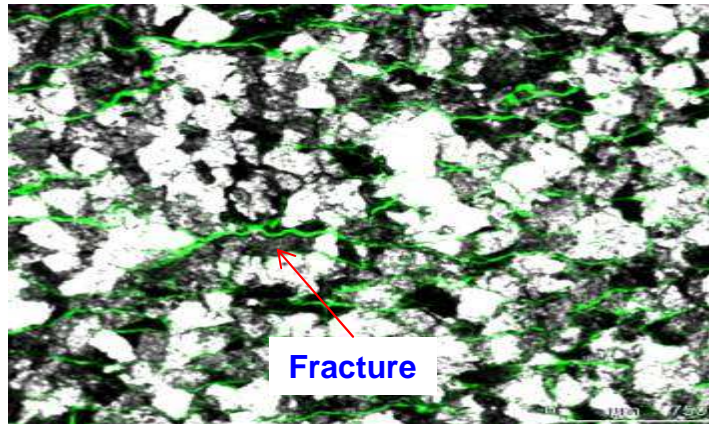
⑥ High Pressure Coefficient and Low Crude Density

Basins	Formation	Ro(%)	Pressure Coefficient	Crude Density (g/cm ³)	Notes
Williston	Upper Devonian	0.6~1.0	1.35~1.58	0.81~0.83	Bakken
S. Texas	Cretaceous	0.5~2.0	1.35~1.80	0.82~0.87	Eagle Ford
Bohai Bay	Shahejie	0.5~2.0	1.30~1.80	0.67~0.85	Liaohe Sag
Bohai Bay	Shahejie	0.5~2.0	1.53~1.80	0.68~0.78	Jiyang Sag
Sichuan	Da'anzhai	0.5~1.6	1.23~1.72	0.76~0.87	Chuanzhong
Songliao	Qingshankou	0.5~2.0	1.20~1.58	0.78~0.87	Gulong Sag
Ordos	Yanchang	0.7~1.2	0.75~0.85	0.70~0.76	Yixia Slope
Qaidam	E System	0.5~0.8	1.47	0.72	Mangya Sag

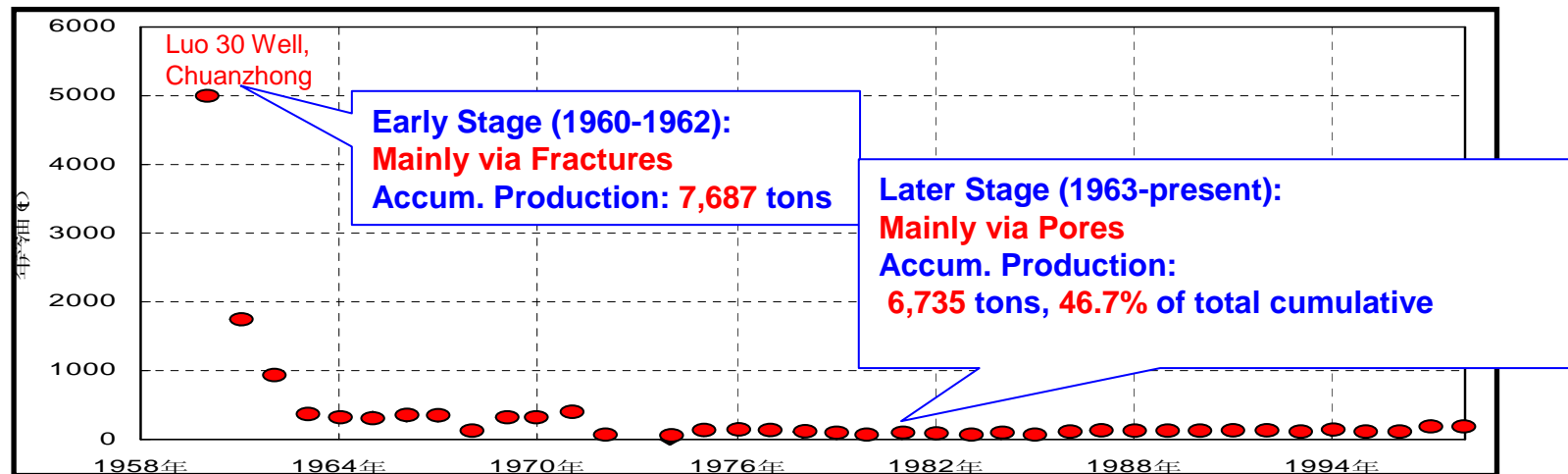
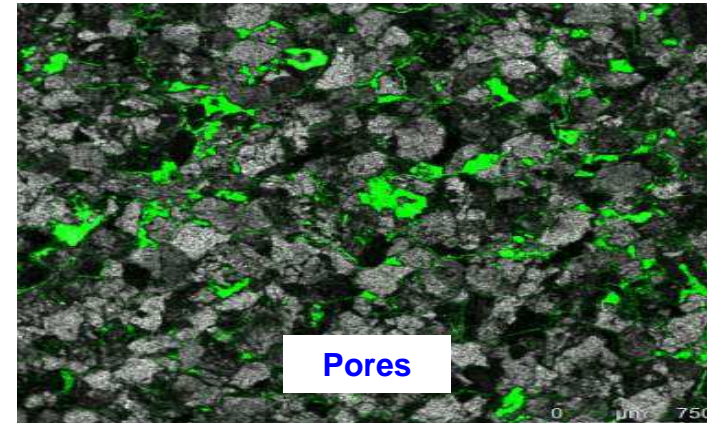
Pressure Coefficient: 1.2-1.8, Density: 0.7-0.9g/cm³

⑦ Rapid Production Decline, Long Production Cycle, Maintaining Production by New Well Drilling

Fractures: Key to High Production



Pores: Main Plays



(Source: Southwest Oil/gasfield, PetroChina)

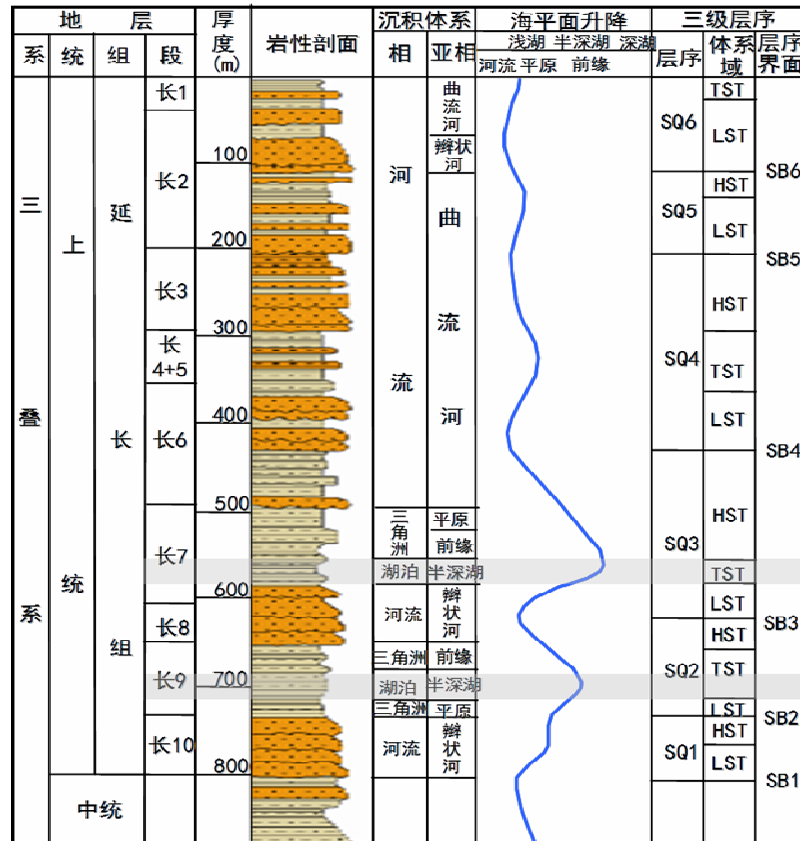
Early Stage: Mainly via Fractures, Later Stage: Mainly via Pores

Table of Contents

- 1. Current Status & Definition of Tight Oil**
- 2. Characteristics of China's Tight Oil**
- 3. Exploration Potentials of Tight Oil in China**

Case 1: Yanchang Formation, Ordos Basin

Strata Sequence Columnar Section,
Yanchang Formation, Yanhe Section



Ordos Mesozoic



- 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

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!

Caring for Energy Caring for You

