

# 14<sup>th</sup> U.S. - China Oil & Gas Industry Forum

## **STATUS OF PETROCHINA TIGHT OIL EXPLORATION AND DEVELOPMENT**



**Research Institute of Petroleum Exploration and Development—**

**PetroChina**

**September, 2014**

## ➤ What Is Tight Oil



- Tight oil, originating in the AAPG Bulletin magazine in the 1940s, is used to describe the oil-bearing tight sandstone. This word appeared almost at the same time with "tight gas". As a professional term, it represents a kind of unconventional oil and gas resources.
- At present, there exists no an agreed standard for the definition of tight oil. In China, tight oil refers to oil accumulation interjacent or adjacent to the high quality oil generative assemblage without a long distance migration. Generally, tight oil has no natural productivity and needs the large scale fracturing to form the industrial capacity.
- The physical property boundary of tight layer is surface air permeability less than 1mD, overburden pressure permeability less than 0.1mD.  
(According to Jia Chengzao, Zou Caineng, Du Jinhu , et. al.)



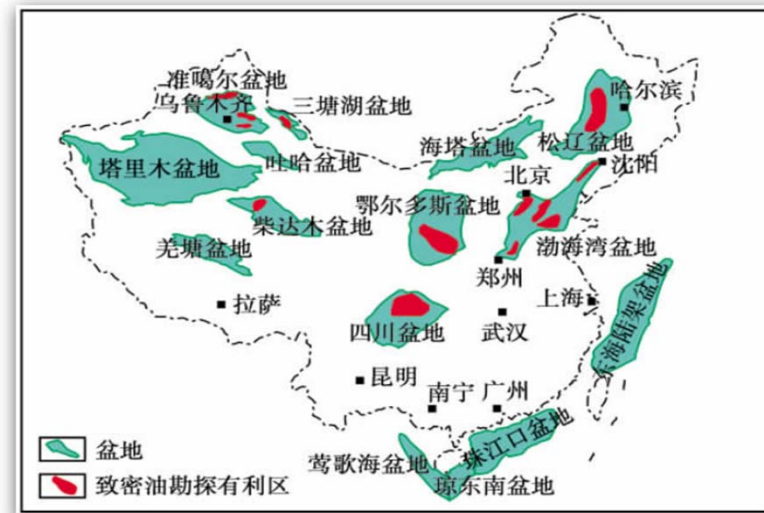
# Outline

- **The present situation of tight oil in China**
- **Key supporting technologies for tight oil exploration and development**
- **Conclusions and understanding**

## ➤ The present situation of tight oil in China

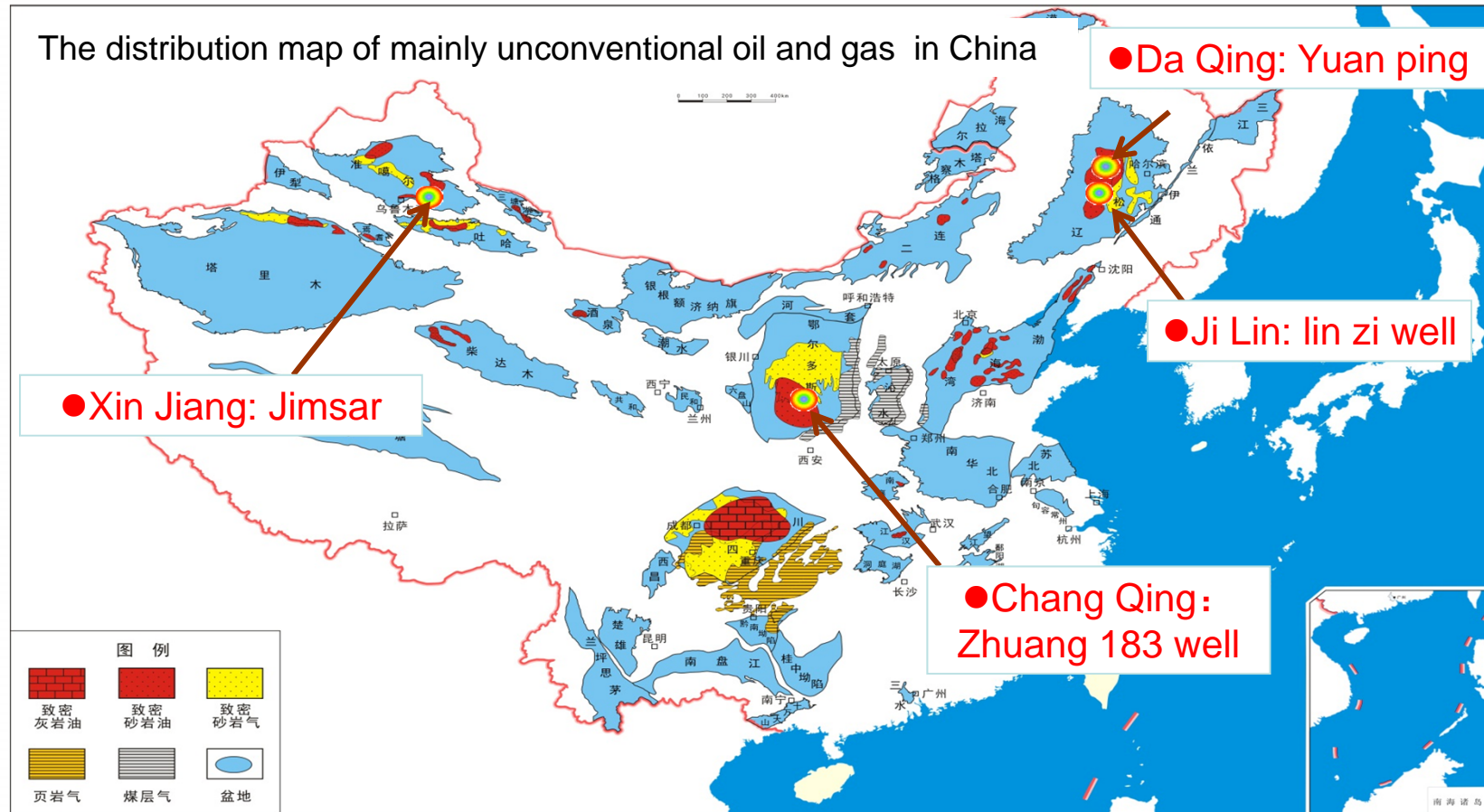


- Start of exploration and development of tight oil in China was fairly late, but the preliminary exploration and research proved favorable resource prospect of tight oil in China. After nearly 3 years of steady development progress, the terrestrial tight oil accumulation theory has already initially formed, four supporting key technologies have been improved, a number of favorable prospecting areas have been found in Ordos, Junggar and Songliao Basins.
- Three billion-ton oil pools
  - Ordos Chang 7
  - Jimsar depression area
  - Fuyu formation in Songliao Basin
- Six hundred-million-ton potential areas
  - Zaha springs, Caidam Basin
  - Tiaohu Group, Santang Lake
  - Conglomerate-marl in Jizhong depression



The distribution map of mainly tight oil basin in China

## ➤ The present situation of tight oil in China



- Opening up 8 tight oil Development Experimental Zones with productivity more than 1 million tons.

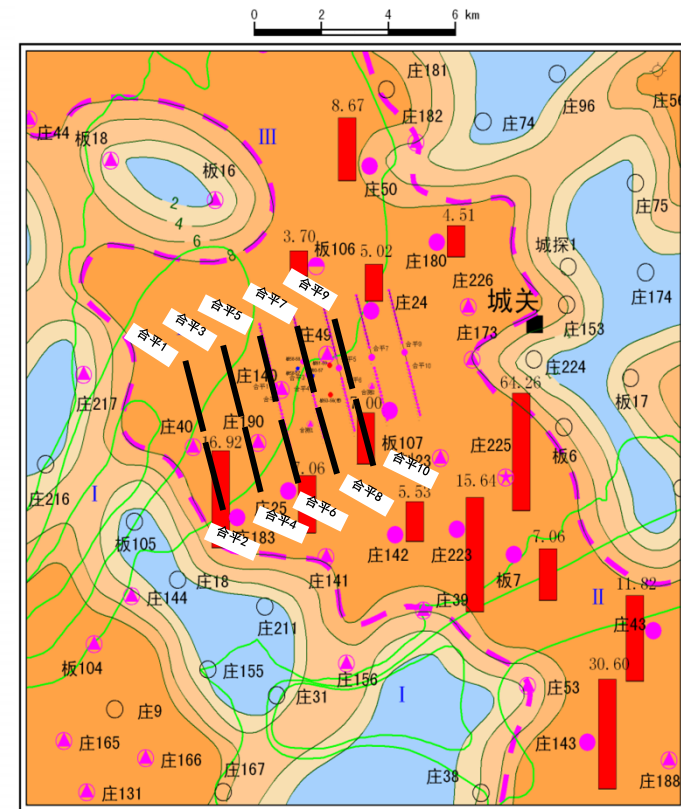


## ➤ The present situation of tight oil in China



Taking Ordos Zhuang 183 tight oil as an example, horizontal wells expanding test has made important progress.

- Up to May, 2014, 10 horizontal wells and 2 monitoring wells drilled
- The horizontal section length: 1500 meters
- The average oil reservoir encountering rate of horizontal wells: 91.4%
- Well completion and well test: 6
- Average well test production: 117.75 m<sup>3</sup>/d  
Maximum well test production: 125.40 m<sup>3</sup>/d



Zhuang 183 horizontal wells test area  
Yanchang group 71 exploration results map



# Outline

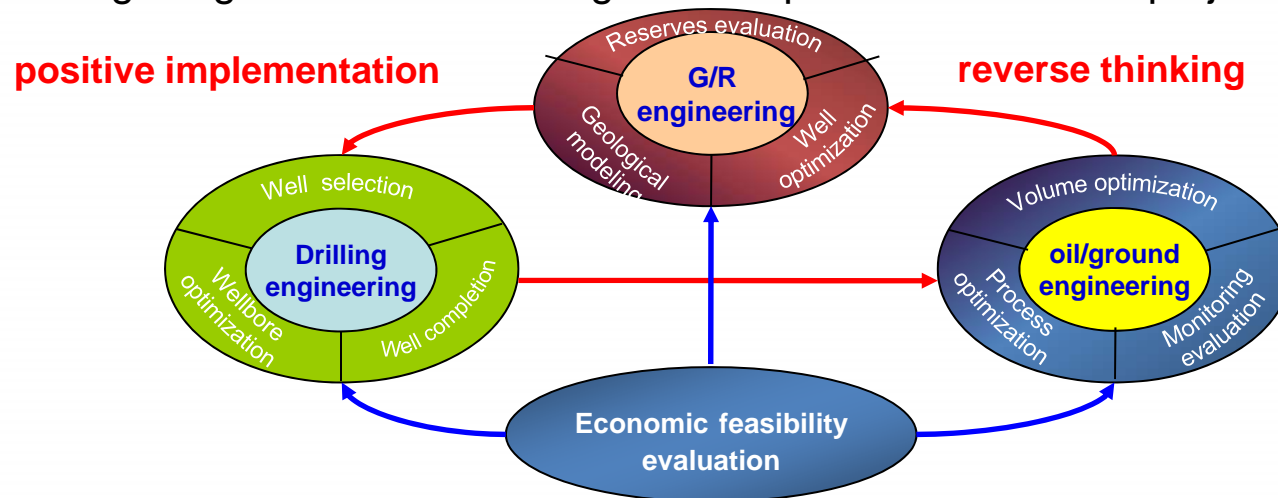
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## ➤ Key supporting technologies for tight oil exploration and development



### 1. Integrated workflow involving exploration, development and engineering technology was established

- Traditional opinion had be changed. Exploration extends backward, while development intervention was performed in advance. “Integration” concept was put into practice.
- Following the "reverse thinking, positive implementation" principle, a data platform was established, which could meet the engineering demand to share information and correct geological model according to the implementation of the project.



Tight oil exploration and development engineering integration strategy

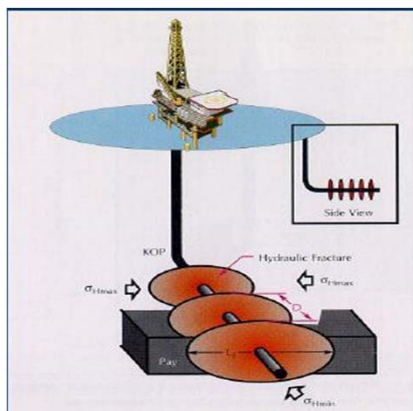


## ➤ Key supporting technologies for tight oil exploration and development

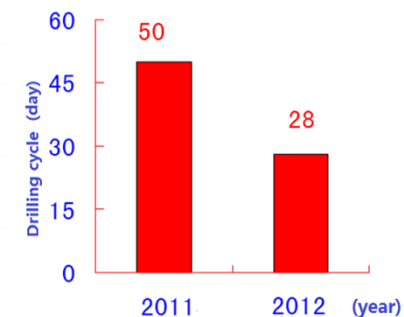
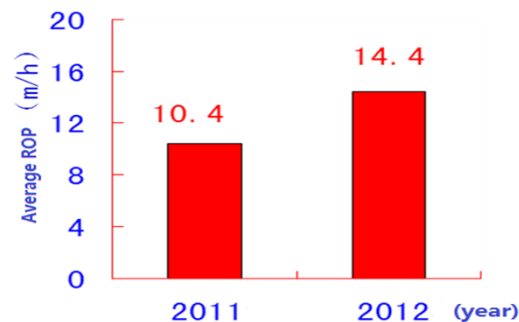


### 2. Well structure, drilling trajectory and horizontal length were optimized. Thus, drilling cycle was shortened and wellbore quality was improved.

- Optimal and fast drilling technology primarily including bit type selection, oil-based drilling fluid and drilling optimization was particularly improved. The drilling cycle is shortened to 25 days from 45 days .
- The large-scale application of trajectory control technology based on rotary steering drilling and measurement while drilling.
- Horizontal section is increased from 800m to 1500m.



The drilling rate of horizontal wells in Changqing Oilfield annual comparison

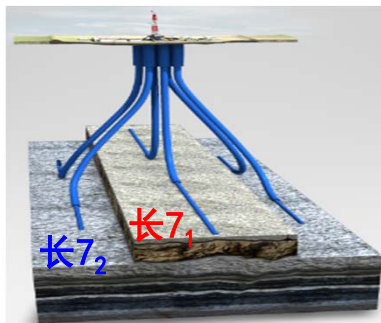


## ➤ Key supporting technologies for tight oil exploration and development



### 3. “Factory” platform type operating mode was adopted, which decreased the development cost sharply.

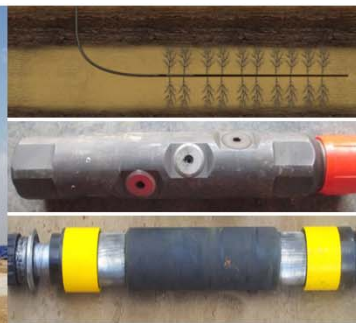
- Innovative development model reduced overall development cost: the development cost was decreased through the factory platform-style operating mode, simplifying ground construction and improving management.
  - **Three-dimensional drilling technology:** cluster wells
  - **Comprehensive utilization of water resources:** 90% produced water recycled
  - **Reducing ground occupation area:** six horizontal wells for one platform, equivalent to 24-vertical-well site
  - **Cost cut:** cost of single well reduced



cluster wells



drilling surface



Effective fracturing technology



Centralized water supply



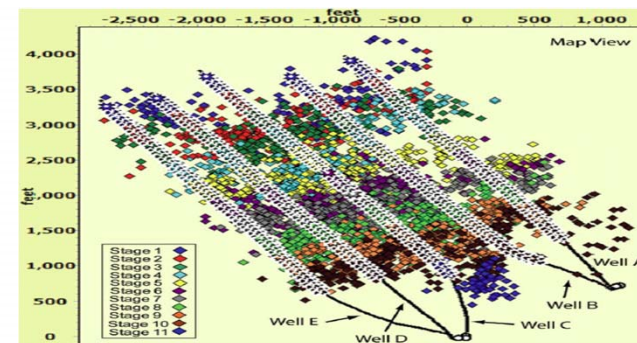
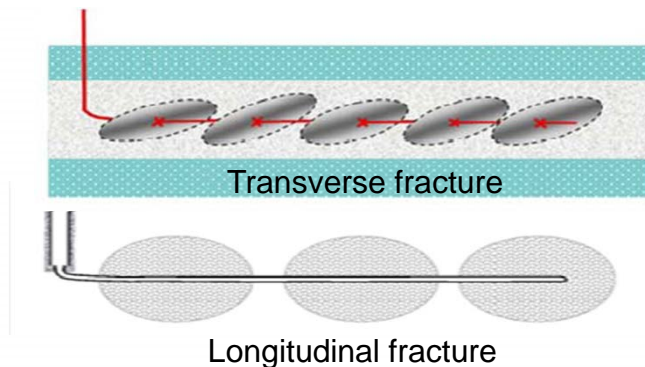
streamline operations

## ➤ Key supporting technologies for tight oil exploration and development



### 4. Stimulated reservoir volume fracturing technology was utilized, thus greatly improving individual well production.

- Since the '11th five-year plan', the company's technical research in the field of staged fracturing technology for horizontal well has greatly improved per well production and succeeded in production of low permeability and extra-low permeability reservoir.
- During the period of '12th five-year plan', continuous research has achieved a major milestone via technology self-perfection, which provided the key technology to enhance stimulation and efficiently produce tight oil reservoir.



Volume fracturing in 2011

Multistage development is refined and the producing degree is improved. Producing lower limit is down to 0.3mD.

Improve the reconstruction volume and start the unconventional resource development.

## ➤ Key supporting technologies for tight oil exploration and development



### (1) The slickwater fracturing fluid system for tight oil fracturing was developed.

- The EM slickwater fracturing fluid system ,with such features as low friction, less damage and reutilization, has been applied more than 1000 times with fluid volume nearly 500000 m<sup>3</sup>. The costs can be reduced over 50%.

The index comparison table between slickwater fracturing fluid system and other system

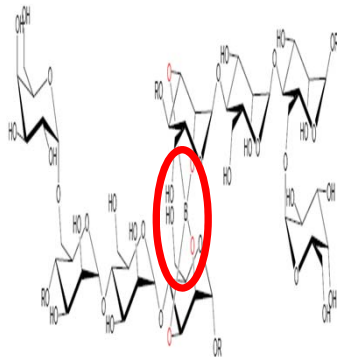
Item	Local slickwater in the past	New slickwater system
Core damage rate	37.52%	15%
Friction reduction rate	38%	62%
Flowback capacity	0.62mN/m	0.42mN/m
Composite cost	480RMB/m <sup>3</sup>	210RMB/m <sup>3</sup>

## ➤ Key supporting technologies for tight oil exploration and development

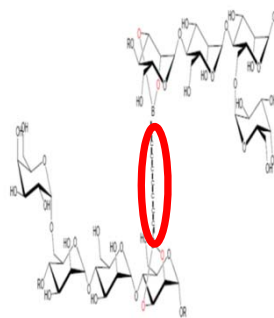
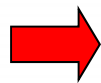


### (2) Successful development of ultra-low concentration fracturing fluid system realized low cost fracturing treatment.

- Newly developed FAL-120 cross linking agent made 0.15% of hydroxypropyl guar (HPG) cross linked, which broke the technical limit of 0.18%.
- This technique has been applied in nearly 10000 wells in Changqing Oilfield, Daqing Oilfield and so on. The cost of fracturing treatment was cut down 600 million RMB.



Conventional cross linking agent system



Cross linking limit down to 0.1% from 0.15%



weak crosslinked gel

The weak crosslinked gel sand carrying condition, and the sand concentration is 20%





## ➤ Key supporting technologies for tight oil exploration and development



### (3) New cellulose fracturing fluid and proppant network management

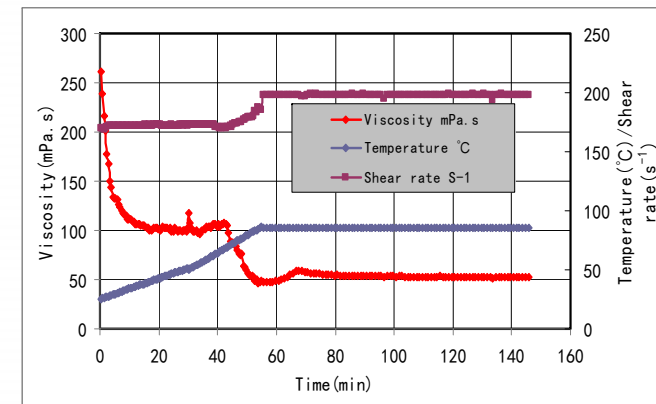
- Aiming at the problems such as the micro throat and greater residue damage to the flow conductivity of natural fractures and artificial fracture, a new type of cellulose fracturing fluid system was developed.
- Research on degradable fiber diversion deflection material was carried out.
- The quality evaluation was launched for Chinese proppant ceramsite, quartz sand, etc by using the proppant network management. The production capacity was about 3.5 million tons, meeting the domestic needs.



Laboratory gel breaker liquid



Slender shaped fiber



The viscosity-temperature curve of fiber carrier fluid

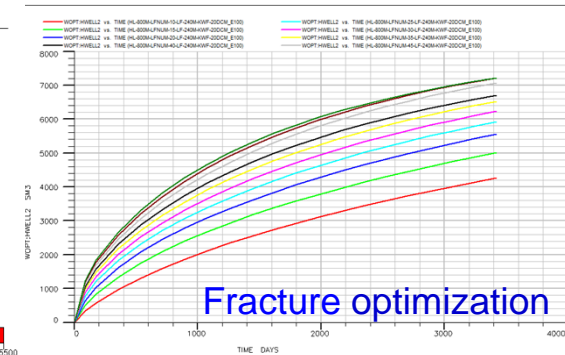
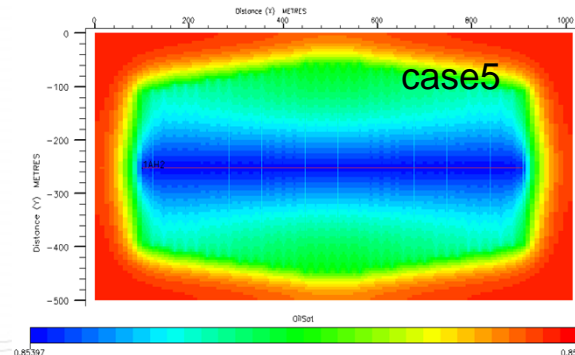
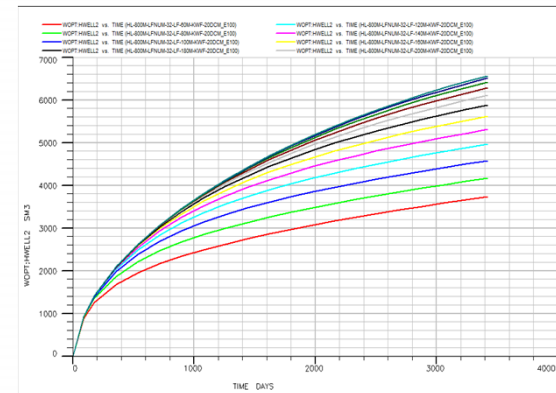
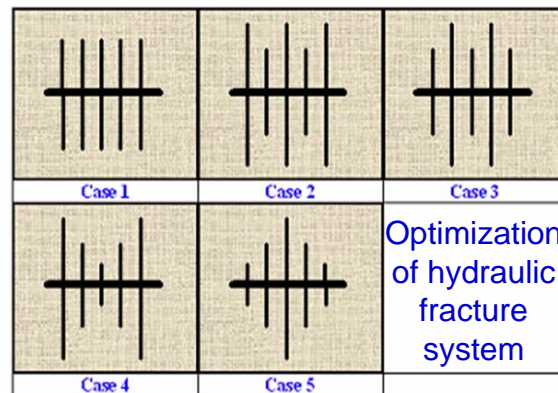


## ➤ Key supporting technologies for tight oil exploration and development



### (4) Design workflow and method for volume fracturing was initially formed for the field application.

- Carrying out large scale rock physical model and fracture numerical simulation for optimization of hydraulic fracture system

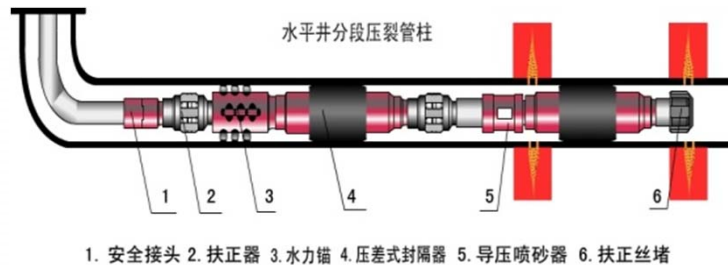


## ➤ Key supporting technologies for tight oil exploration and development



- Targeting at the multi-section and multi-layer treatment in low permeability reservoir , eight sets of vertical multilayer fracturing and horizontal well multistage technology were developed.
- By 2013, 514 wells and 3871 sections of horizontal wells fracturing had been accomplished. And 90% of down hole tools developed independently were used.

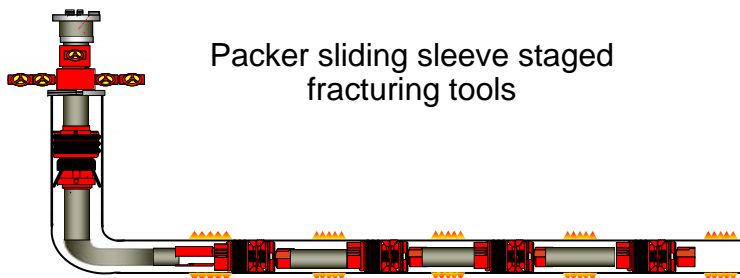
Double plugging and single block staged fracturing tools



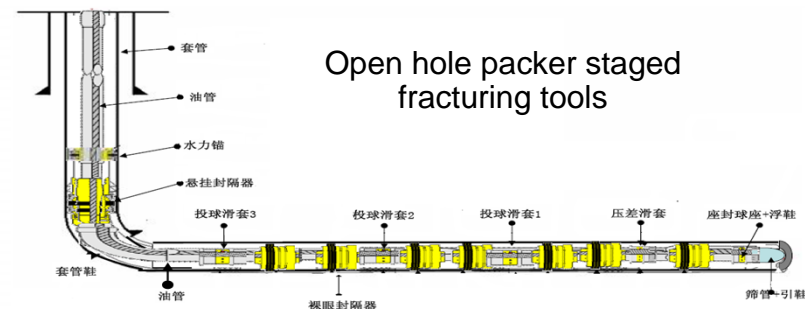
Hydraulic sand blasting staged fracturing tools



Packer sliding sleeve staged fracturing tools



Open hole packer staged fracturing tools



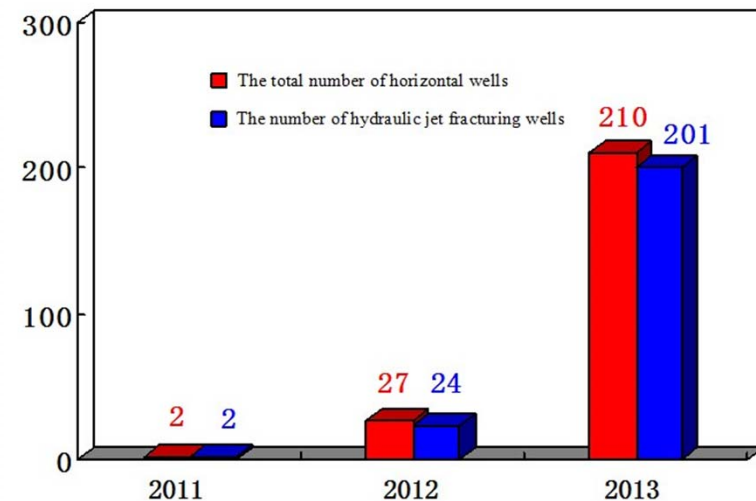
## ➤ Key supporting technologies for tight oil exploration and development



- Taken as an example, hydraulic jetting has been a mature technology in Changqing Oilfield. The max fracturing stages for single well reached 24. And also, the infinite order fracturing can be achieved by dragging the string.
- The objective of fracturing by one-trip string was achieved, and the maximum fracturing stages reached 12.
- Up to now, it has been cumulatively applied in 227 wells and more than 2200 sections of horizontal wells for tight oil development.

**The operating capacity comparison of hydraulic jet single-trip string**

	conventional fracturing	volume fracturing
Pumping rate	6 m <sup>3</sup> /min	10 m <sup>3</sup> /min
Stages	1 stage 2 clusters	12 stage 24 clusters
total volume of sand	120 m <sup>3</sup>	800 m <sup>3</sup>
total volume of fluid	1200m <sup>3</sup>	6400 m <sup>3</sup>



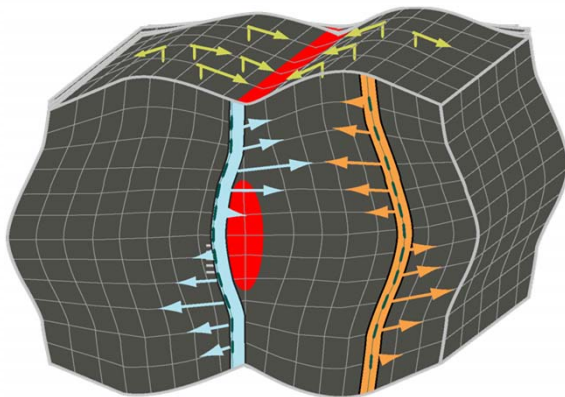
The illustration of hydraulic jet fracturing technology application for tight oil horizontal well

## ➤ Key supporting technologies for tight oil exploration and development

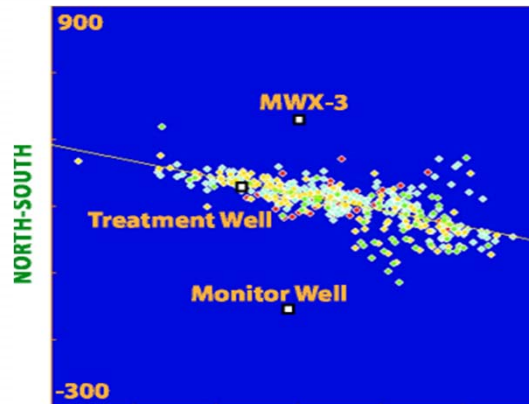


### (5) Post-fracturing analysis

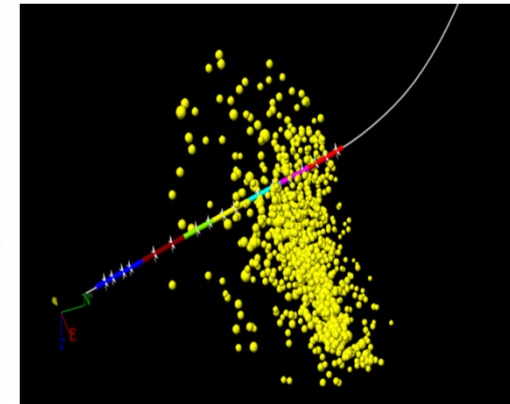
- The advanced tiltmeter and microseismic monitoring devices were introduced and fracture interpretation method was improved.
- It has the microseismic monitoring experience in 14 oilfields and about thousand of microseismic monitoring projects were completed.



Hydraulic fracture tiltmeter



Downhole microseismic



Microseismic event orientation



## ➤ Key supporting technologies for tight oil exploration and development



### (6) Equipments with high power

- By the end of 2013, Petrochina had 492 sets of fracturing pump trucks with total capacity about 910700 hydraulic power. Amongst, home-made trucks accounted for 49.4%. The company has the production capacity of 2500 and 3000 type fracturing pump truck.

#### ■ Main equipments

- fracturing pump truck
- blender
- instrument (command) truck
- manifold truck

#### ■ Corollary equipments

- continuous mixed-ligand equipment
- continuous sand conveyance equipment
- coiled tubing truck
- liquid nitrogen truck

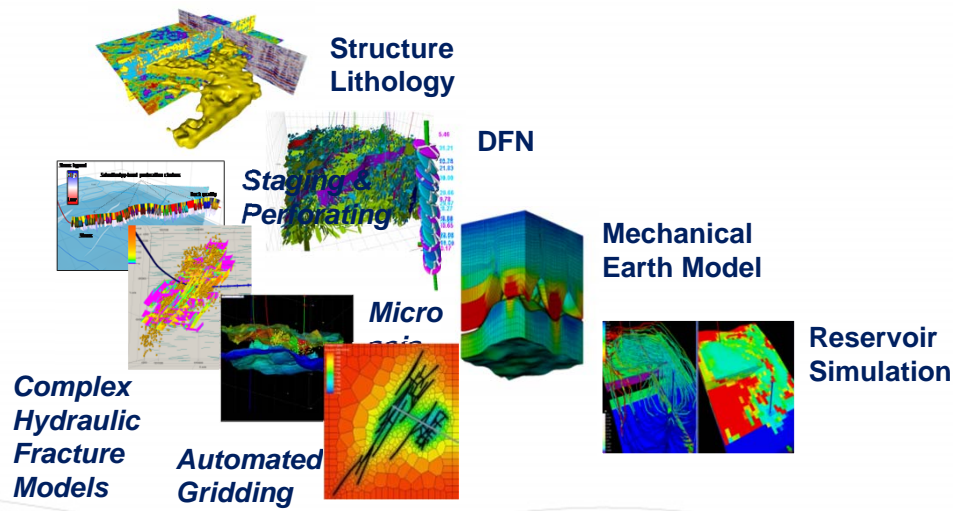


## ➤ Key supporting technologies for tight oil exploration and development



### (7) Strengthening the cooperation and exchanges with the international oil companies, drawing lessons from foreign experience and mature technology and accelerating the development of tight oil

- Technical cooperation and meetings with international companies such as Schlumberger etc. for advanced technology communications.
- Block operation cooperation with SHELL and HESS in Santanghu basin.







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## ➤ Conclusions and Understanding



- The resources of tight oil has favorable commercial prospect in China. After nearly three years of exploration and development activities, three reserve areas of over hundred million tons have initially formed and six new discovery have been gained.
- Compared with marine facies tight oil in North America, due to its complexity and particularity, the land facies tight oil development in China should be carried out on the basis of research on geological evaluation and reservoir reformation technology applicable for the reservoir characteristics of tight oil in China.

Block	Buchan oilfield	Changji oilfield	Cang 7 in Ordos	Permian system in Tuha oilfield
depositional environment	marine deposit	continental deposit	continental deposit	ontinental deposit
oil-bearing formation	Bakken formation	Lucaogou formation	Yanchang formation	Tiaohu formation
depth(m)	2591-3200	2300-4000	1000-2800	2000-3000
natural fracture	developed	local developed	developed	well developed
porosity(%)	10-15	11	9.2	10.9-16.2
permeability(mD)	0.005-0.1	0.03-0.07	0.17-0.24	0.01-0.1

## ➤ Conclusions and Understanding



- With the progress of engineering and technology, especially the extensive application of horizontal well drilling and stimulated reservoir volume fracturing technology, as one primary means for tight oil exploration and development in China, greatly reduces the cost and enhances the single well production.
- It does not matter whether Bakken Oilfield in North America or Ordos tight oil oilfield in China, such technical problems exists as dramatic production decline and stable production difficulty. The fundamental researches on three integrations, exploration and development, geology and engineering as well as research and production, should be pushed forward. At the same time, the international cooperation and exchanges in tight oil is needful to prompt exploration and development technology.



# Thank you!