Shale basins and assessment of shale energy resources in China

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Outline

Main shale basins and geological conditions

Data collected to calculate the volume
1.1 Main shale basins in China

The China geologist had found a series petroliferous basins, and established many big oilfields in China. Now there are 6 main shale basins in China.
1.2 Geological Conditions of Shale gas

Shale gas of China mainly developed in 3 facies, 9 areas and 16 formations.

- South Paleozoic facies: Lower Cambrian, Upper Ordovician-lower Devonian, Carboniferous, Permian in south.
- East rift basin, Upper Jurassic in Sichuan and basin, Triassic Erdos, northwest area, northeaast area.
- Transitional facies: North of Carboniferous, Permian in south.

Potential areas of shale gas in China:
- Northwest Jurassic
- Erdos basin Triassic
- Sichuan and around basin, Upper Triassic-lower Jurassic
- North China Carboniferous Permian
- North Carboniferous Permian
- Transitional facies in south Permian
- East rift basin Paleogene
- Northeast Cretaceous
- South marin facies Sinian, lower Cambrian, upper Ordovician-lower Silurian, Devonian, Carboniferous
### 1.2 Geological Conditions of Shale gas

The shales have wide regional distribution, great single layer thickness, high TOC, degree of thermal evolution, develop rich micro - nano-pores, brittle mineral-rich, great prospects for shale gas.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Facies</th>
<th>Thickness (m)</th>
<th>TOC(%)</th>
<th>Kerogen type</th>
<th>Ro (%)</th>
<th>Depth (m)</th>
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<tbody>
<tr>
<td>O₂₃</td>
<td>Slope-Basin</td>
<td>30-100</td>
<td>1.33-4</td>
<td>II1—II2</td>
<td>1.3-2.2</td>
<td>2800-5200</td>
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<tr>
<td>O₃-S₁</td>
<td>Platform</td>
<td>40-210</td>
<td>1.0-3.7</td>
<td>I</td>
<td>1.8-3.2</td>
<td>500-4500</td>
</tr>
<tr>
<td>O₃</td>
<td>Platform-depression-margin slope</td>
<td>70-200</td>
<td>0.48-1.08</td>
<td>I</td>
<td>0.57-1.5</td>
<td>1500-3000</td>
</tr>
</tbody>
</table>

**15 formations**

- South [6]
  - Jiusi(C₁j)
  - Yintang-Luofu(D₂3y-l)
  - Wufeng-Longmaxi(O₃w-S₁l)
  - Dachengsi(O₂d)
  - Qiongzhusi(ε₁q)
  - Doushantuo(Z₂d)

- North China [3]
  - Pingliang(O₁p)
  - Xiamaling(Pt₃jx)
  - Hongshuizhuang(Pt₃jx)

- Tarim [3]
  - Yingan(O₁y)
  - Saergan(ε₃-O₁s)
  - Tueryusi(ε₁t)

- Qiatang Xiali(J₁x)
1.2 Geological Conditions of Shale gas

Transitional shales with a great total thickness but small single layer thickness, high medium content brittle mineral, has good prospects for shale gas
1.2 Geological Conditions of Shale gas

Shale gas is a major unconventional natural gas with a great total thickness, high TOC, but low degree of thermal evolution overall and low content brittleness mineral, some prospect of gas

<table>
<thead>
<tr>
<th>Area</th>
<th>formation</th>
<th>Facies</th>
<th>Thickness (m)</th>
<th>TOC(%)</th>
<th>Kerogen type</th>
<th>Ro (%)</th>
<th>Depth (m)</th>
</tr>
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<tbody>
<tr>
<td>Sichuan Basin</td>
<td>J</td>
<td>Lacustrine</td>
<td>120-240</td>
<td>1.2-2.0</td>
<td>II</td>
<td>0.8-1.6</td>
<td>1000-3500</td>
</tr>
</tbody>
</table>

8 formations

- **Songliao [2]**
  - 1st Qingshan Kou (K1q1)
  - 2ed-3rd Qingshan Kou (K1q2-3)
- **Bohai Bay [3]**
  - 1st Shahejie (Es1)
  - 3rd Shahejie (Es3)
  - 4th Shahejie (Es4)
- **Ordos [3]**
  - 7th Chang (T3ch7)
  - 9th Chang (T3ch9)

*Scenes in Yuanlu4 Well 3789.24m, Daanzhai shale in Yuanlu4 Well 3892.24m*
1.3 Exploration and Development Progress

Important breakthrough and 3 progress of shale gas in China

**Breakthrough 1:** Marine facies in Lower Paleozoic South Jiaoye HF1 well: 203 thousand m³/d Ning 201-H1 well: 150 thousand m³/d

**Breakthrough 2:** Continental facies in Upper Triassic-lower Jurassic in Sichuan and around basin Xinye HF1 well: 46 thousand m³/d Yuanba21 well: 507 thousand m³/d

**Breakthrough 3:** Continental facies in Triassic Erdos Liuping177 well: 2350 m³/d Xin57 well: 2413 m³/d

**Progress 1:** Continental facies in Jurassic northwest area Chaiye1 well: 3 section shale oil and gas, thickness 140.5m

**Progress 2:** Continental facies in East Paleogene rift basin Anshen1 well: Shale oil 4.68t/d Miye1 well: Shale oil 20.4t/d

**Progress 3:** Transitional facies in Upper Paleozoic south Xiangye1 well: 2409.9 m³/d
1.3 Exploration and Development Progress

Through 1: Exploration of shale gas achieves major breakthrough from Lower Silurian basins in south China, development test made important progress.

Marine facies –Jiaoye 1HF well Hydraulic fracturing and Gas Production Test, can yield gas at a rate from Longmaxi formation Silurian.
1.3 Exploration and Development Progress

Through 1: Exploration of shale gas achieves major breakthrough from Lower Triassic basins in south China, development test made important progress

Depth map of Longmaxi formation Shale rocks in Shunan area
1.3 Exploration and Development Progress

Though 2: shale gas have been found in Triassic & Jurassic
tal facies source Rocks in Sichuan Basin

YB 21 well tested gas in Daanzhai layer
507 thousand m³/day

High gas flowing from lower Jurassic layer in Yuanba area of the Sichuan Basin
1.3 Exploration and Development Progress

Through 3: shale gas have been found from continental facies shale in Triassic Sheng Formation and Transitional facies shale in Ordos Basin.
1.3 Exploration and Development Progress

Shale gas have been found from continental facies shale in Qaidam.
1.3 Exploration and Development Progress

Result 2: Shale oil have been found from Paleogene of fault depression in Eastern China.

- Miyang Depression: Anshen-1 well, Miye-HF1 well
- Lihe Depression: Shae 165 well, Shba 224 well
1.3 Exploration and Development Progress

Class 3: Shale gas flow have been found from Transitional facies of strata in South China

Xiangye 1 well in Xiangzhong area, Upper Permian

- Cumulative gas production 54721.23m³
- Oil production 1005.48m³
- Maximum value 2409.9m³/Day
Outline

Main shale basins and geological conditions

Data collected to calculate the volume
2.1 Shale formation boundary maps

Junggar basin
2.1 Shale formation boundary maps

Bohai Bay basin
2.1 Shale formation boundary maps

Tarim basin
2.1 Shale formation boundary maps

Sichuan Basin
2.1 Shale formation boundary maps
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2.1 Shale formation boundary maps

Maps by QGis
2.1 Shale formation boundary maps

Maps by QGis
### 2.2 Samples and datas

<table>
<thead>
<tr>
<th>Number</th>
<th>Sample name</th>
<th>Stop</th>
<th>Date</th>
<th>Basin</th>
<th>Formation</th>
<th>UTM (Y)</th>
<th>UTM (X)</th>
<th>Coordinates (Y)</th>
<th>Coordinates (E)</th>
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<tr>
<td>1</td>
<td>C-1</td>
<td>Xinghuo1</td>
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<td>Tarim</td>
<td>Yuertusi</td>
<td>41° 32'</td>
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<td>3</td>
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<td>Junggar</td>
<td>Dishulqian</td>
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<td>108° 24' 25.3024''</td>
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<td>Ordos</td>
<td>Yanchang</td>
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<td>Bohaiyin</td>
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<td>Bohaiyin</td>
<td>Dongying</td>
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<td>38° 38' 57.7422''</td>
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<td>16</td>
<td>C-16</td>
<td>S101</td>
<td>20160911</td>
<td>Songliao</td>
<td>Shahezhi</td>
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<td>124° 22' 36.352''</td>
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<tr>
<td>17</td>
<td>C-17</td>
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<td>Songliao</td>
<td>Shahezhi</td>
<td>45° 24'</td>
<td>95.6756''</td>
<td>124° 22' 36.352''</td>
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<td>C-18</td>
<td>Ying52</td>
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<td>Songliao</td>
<td>Qingshan Kou</td>
<td>21678875.2</td>
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<td>46° 4' 55.1784''</td>
<td>124° 1' 12.5184''</td>
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<td>5103683.5</td>
<td>46° 4' 55.1784''</td>
<td>124° 1' 12.5184''</td>
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</table>

20 samples in 6 basins in China
2.3 Resource evaluation

Distribution of Hydrocarbon source rock of Qaidam Basin
2.3 Resource evaluation

Thickness Map of Lower Jurassic Huxishan Formation Muddy Shale in N Qaidam Basin
2.3 Resource evaluation

Plane distribution

Thickness Map of Middle Jurassic Dameigou Formation Muddy Shale in N Qaidam Basin

Sedimentary of muddy shale moved to SE and mainly distributed from...
2.3 Resource evaluation

\[ Q_T = 0.01 \cdot A \cdot h \cdot \rho \cdot q \]

- \( Q_T \): Shale gas geological resources, \(10^8 \text{m}^3\)
- \( A \): Distribution area of gas-rich shale, \(\text{km}^2\)
- \( h \): Effective thickness of shale, \(\text{meter}\)
- \( \rho \): Shale density, \(\text{ton/m}^3\)
- \( q \): Total gas content, \(\text{m}^3/\text{ton}\)
2.3 Resource evaluation

Geological resources (P50) of shale gas in N Qaidam basin **1.38 trillion cubic**, with recoverable resources **2.75 hundred billion cubic meter**

<table>
<thead>
<tr>
<th>Shale gas evaluation area</th>
<th>P5</th>
<th>P25</th>
<th>P50</th>
<th>P75</th>
<th>P95</th>
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<tbody>
<tr>
<td>Lenghu (upper)</td>
<td>3725</td>
<td>3121</td>
<td><strong>2728</strong></td>
<td>2339</td>
<td>1936</td>
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<tr>
<td>Lenghu (lower)</td>
<td>2065</td>
<td>1730</td>
<td><strong>1512</strong></td>
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<td>950</td>
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<td>Honshan</td>
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<td>4824</td>
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<td><strong>Geological resources</strong></td>
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Thanks for your attention.