

New Horizons and Technology for the Petroleum Exploration in China*

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Abstract

China, located in the eastern Euroasian plate, consists of small cratons and orogenic belts. Following successive tectonic movements including the latest Himalayan orogeny, many types of sedimentary basins developed including cratonic-superimposed basins, rifted basins, and residual basins, among others. These basins are characterized by small cratons, large orogenic belts, and strong heterogeneity. The total recoverable petroleum resources in China are estimated to be 25.5 billion tons of oil and 27 tcm of gas, of which 7.4 billion tons of oil and 3.4 tcm of gas are proven reserves. The cumulative oil and gas production in China stands at 18.1 billion tons and 24 tcm, respectively. As the proven reserve/resource rate is relatively low, giant oil and gas fields remain to be discovered. Exploration targets fall within six different categories: litho-stratigraphic traps, subtle traps in mature basins, foreland basins, deep marine carbonates, and volcanic rocks in superimposed basins, frontier subaerial basins, and offshore region. Unconventional resources, such as coalbed methane, oil sands, and oil shales remain to be explored and utilized. New petroleum play concepts, improved exploration and engineering technologies, and the integration of people, technology and business approaches have contributed greatly to the exploration successes in many of the sedimentary basins in China.



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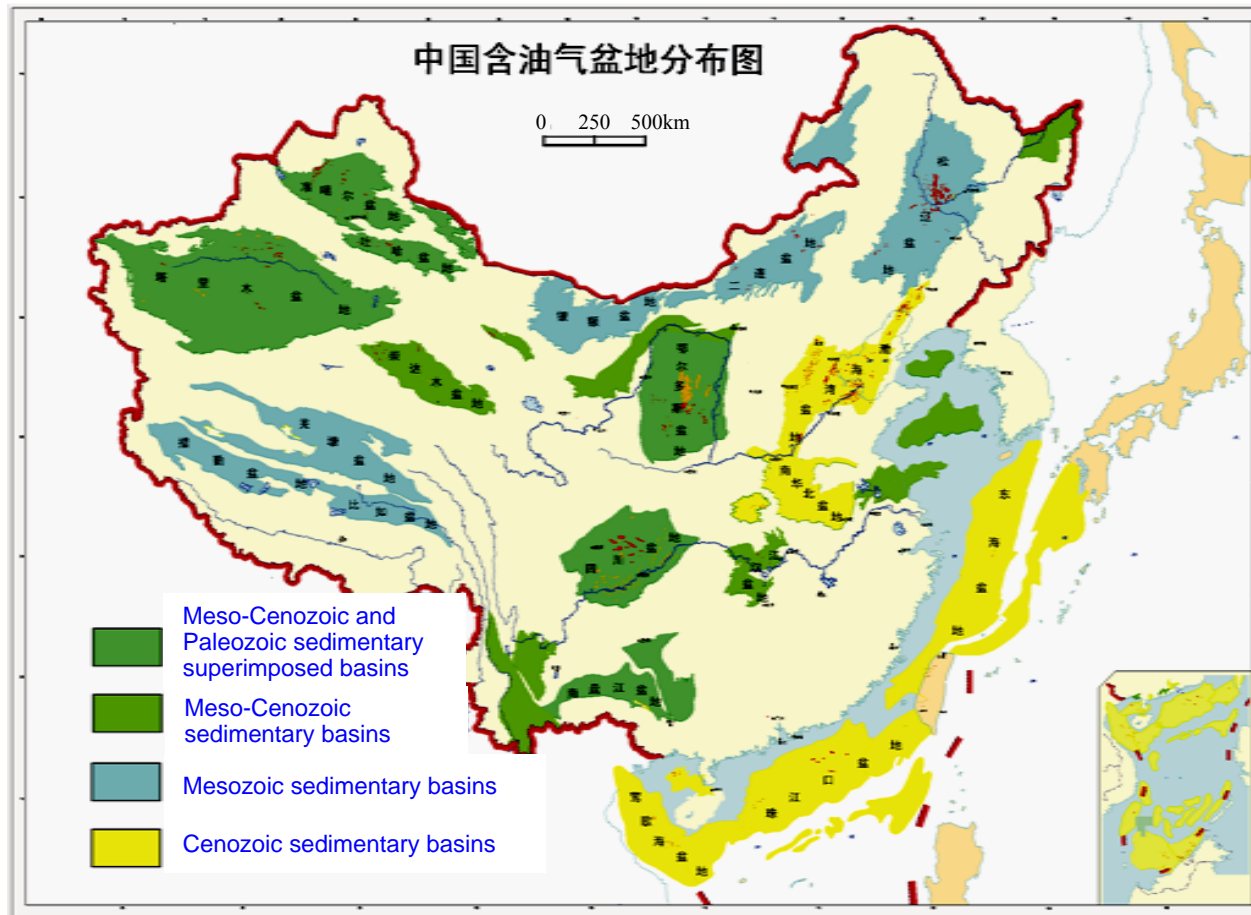
2. Onshore New Discoveries in China

- Shoal --- Jidong Oil Field
- Tight Sands Gas Field --- Xujiache Formation, Sichuan Basin
- Volcanic Gas Field --- Carboniferous, Junggar Basin

3. Application of 3D Seismic Techniques Onshore



Sedimentary Basins in China



- 505 sedimentary basins with a combined area of 6.7million km²
- Resource base: oil 25.5 billion tons (BT), gas 27.5 TCM
- 613 oil fields and 223 gas fields discovered in 32 basins by 2007



Business Indicators of PetroChina in 2007

PetroChina is the largest domestic oil and gas producer and distributor, playing a dominant role in the oil and gas E&P and emerging business in China.

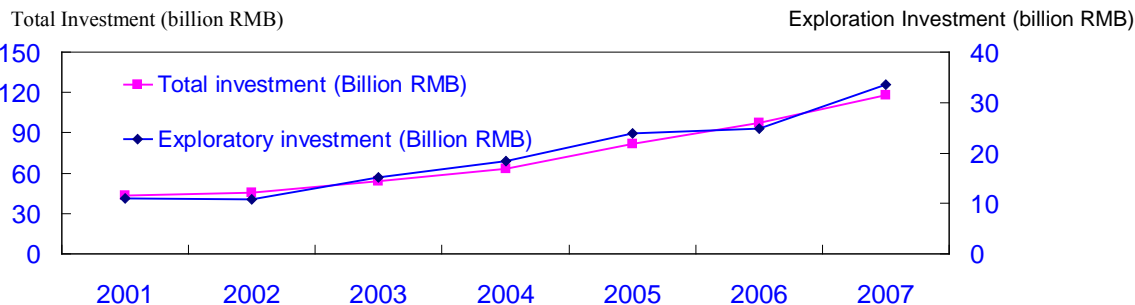
- **Reserve Addition:** Oil 173 million tons (MT) , gas 222.7 BCM
- **Production:** Oil 108 MT and gas 54.2 BCM (57% and 78% of China's production)
- **Remaining Reserves:** Oil 1.89 BT, gas 2.24 TCM
- **Domestic Crude Processing:** 121.73 MT, Oil Products 76.81 MT
- **Overseas Production:** 60.23 MT of oil equivalent



PetroChina's Recent E&D Activities and Investment

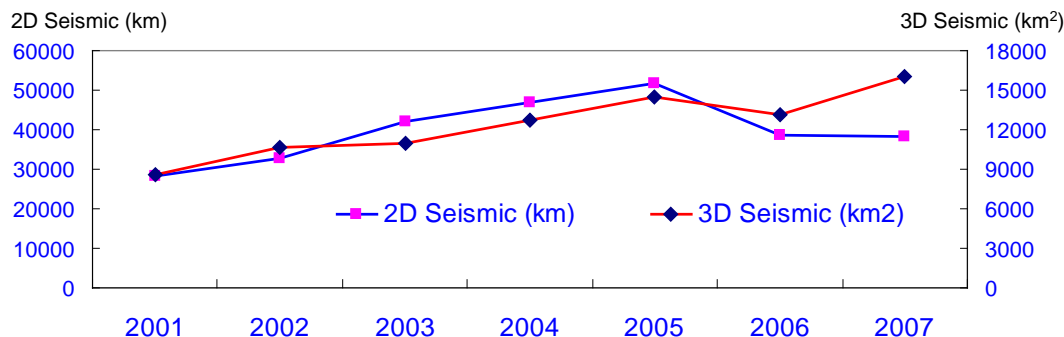
● Exploratory Investment in 2007

- ★ \$4.7 billion US (26% of total investment)
- ★ Annual increased by 16.2%



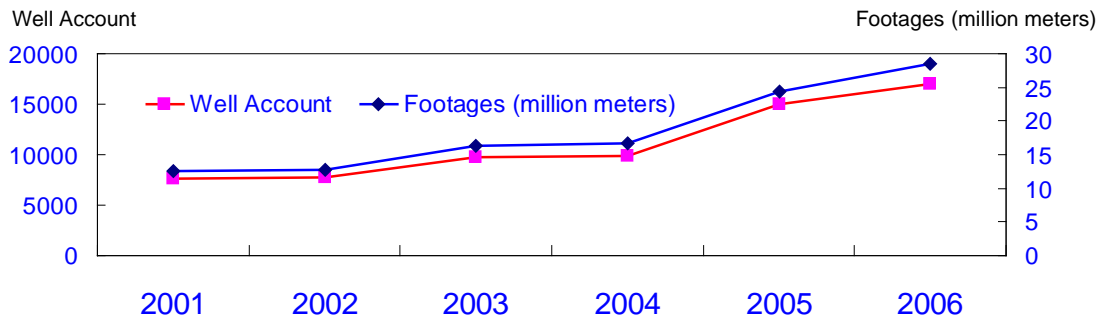
● Seismic Activities in 2007

- ★ 2D: 38243 km
- ★ 3D: 16083 km²
- ★ Annual increased by 8-9%



● Drilling Activities in 2007

- ★ Well number: 14041
- ★ Footages: 25.97 million meters
- ★ Annual increased by 11-12%



PetroChina's E&D activities have been increasing steadily, along with substantial increase in investment.



Major Exploration Domains in China

Remaining Oil/Gas Resources in China

Domains		Oil (Billion tons)			Gas (TCM)		
		Resources	Cum. Proved Reserves	Rem. Resources	Resources	Cum. Proved Reserves	Rem. Resources
Conventional	Stratigraphy	6.588	1.85	4.738	3.65	1.28	2.37
	Foreland Basin	3.359	1.171	2.188	5.19	0.85	4.34
	Carbonates & Volcanics	2.705	0.353	2.352	4.87	0.79	4.08
	Mature	4.538	3.603	0.935	1.29	0.4	0.89
	New Basins Onshore	1.086	0	1.086	1.8	0	1.8
	Sea Area	7.214	0.63	6.584	10.7	0.36	10.34
	Sum	25.49	7.607	17.883	27.5	3.68	23.82
Unconventional		Tar Sands Oil, Shale Oil 10.7-11.1			Coal-bed Methane		
					10.86	0.06	10.8



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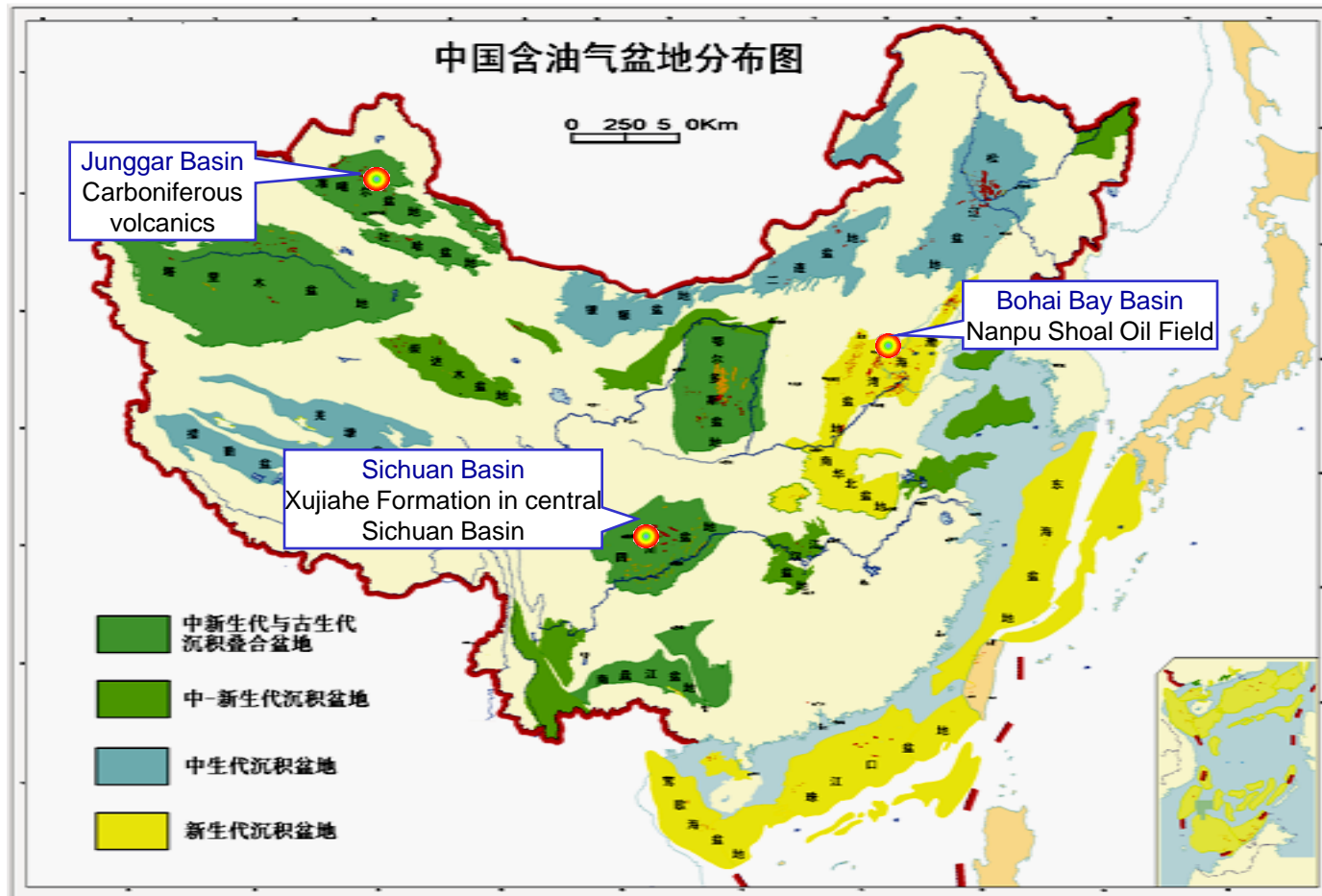
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Onshore New Discoveries in China



- **Oil Exploration:** 6 significant new discoveries in basins of Songliao, Bohai Bay, and Ordos
- **Gas Exploration:** 9 significant new discoveries in basins of Songliao, Sichuan, Ordos, Tarim, and Junggar.



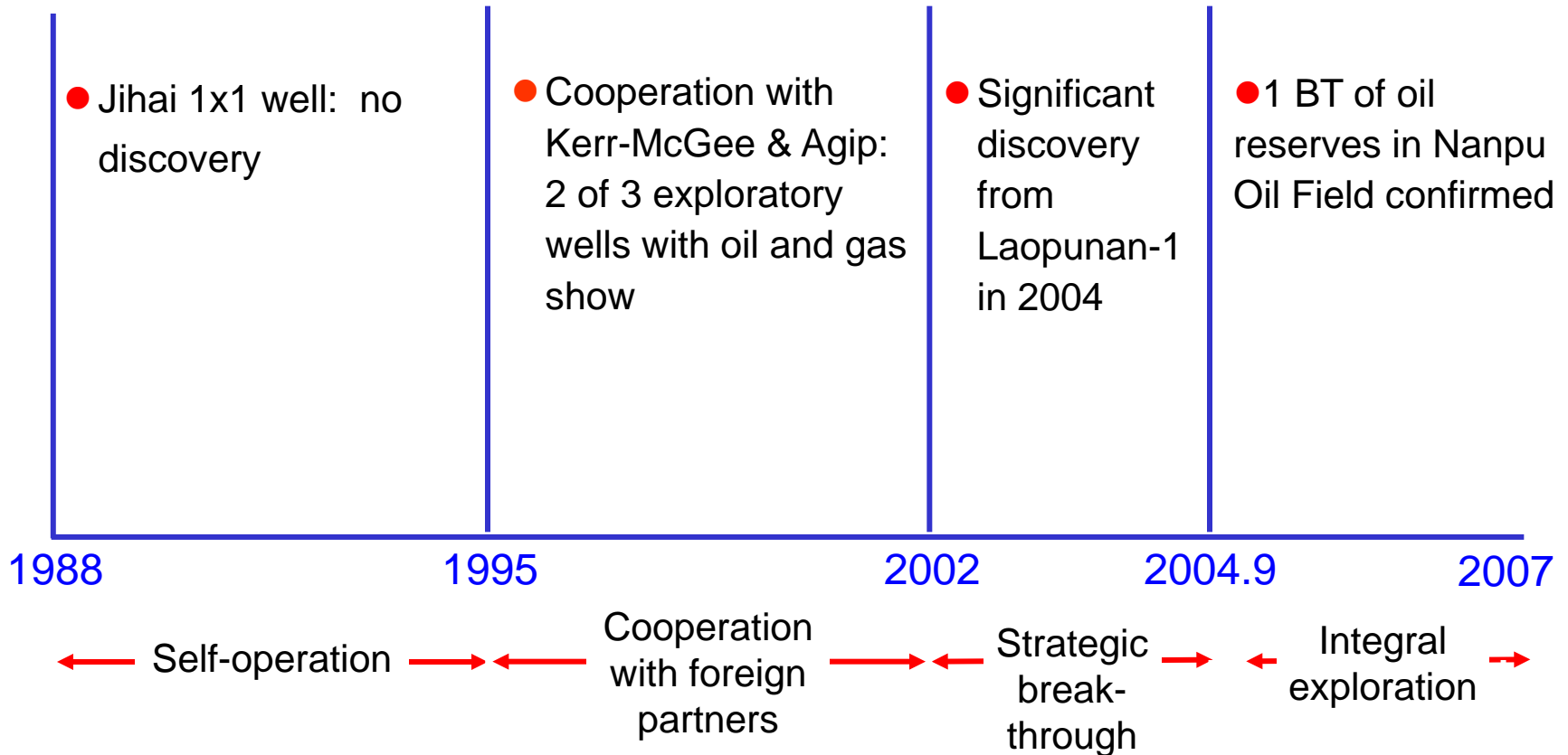
1 New Discovery in Shoal --- Jidong Nanpu Oil Field



Nanpu Depression

- Area: 1570 km²
 - Land: 570 km²
 - Shoal: 1000 km²
- Resource Base: 2.24 BT
 - Land: 0.8 BT
 - Shoal: 1.44 BT
- Nanpu Oil Field located in the shoal area of Nanpu Depression

Exploration History of Nanpu Oil Field



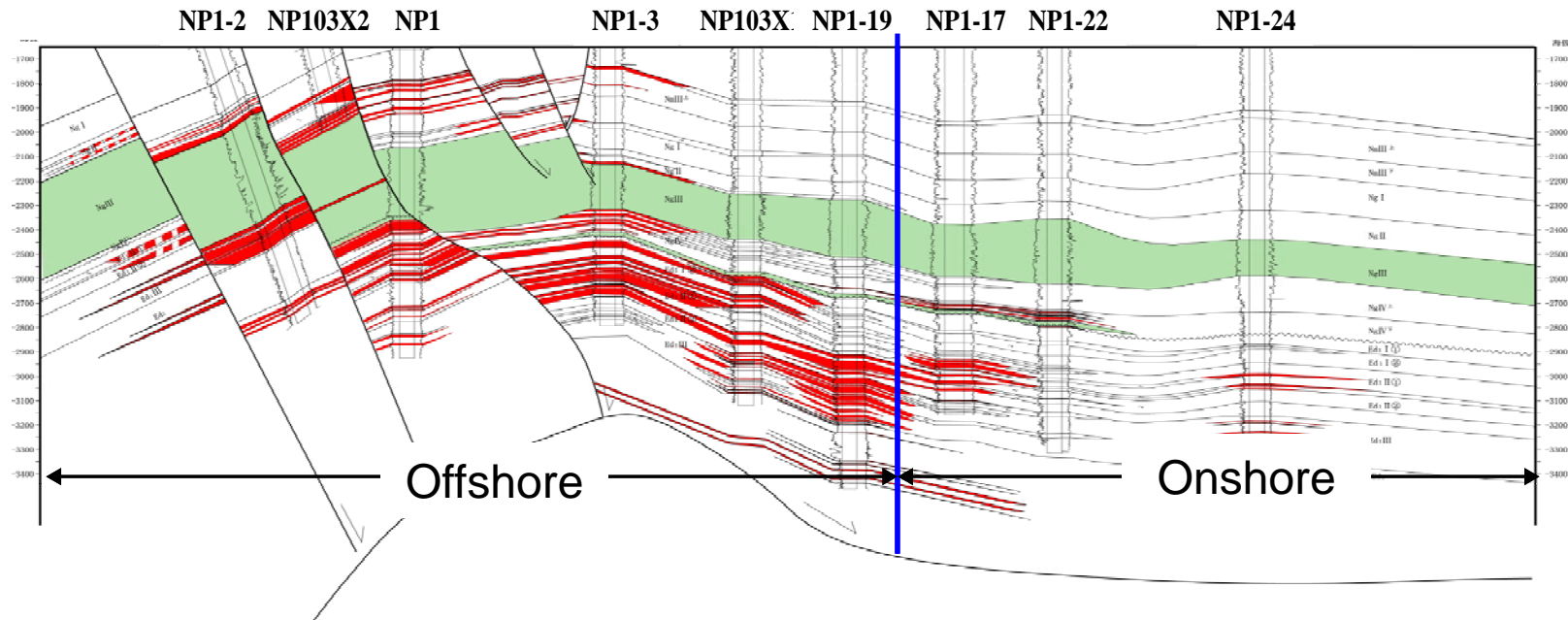
Significant breakthrough in Laopunan-1 Well

September 2004



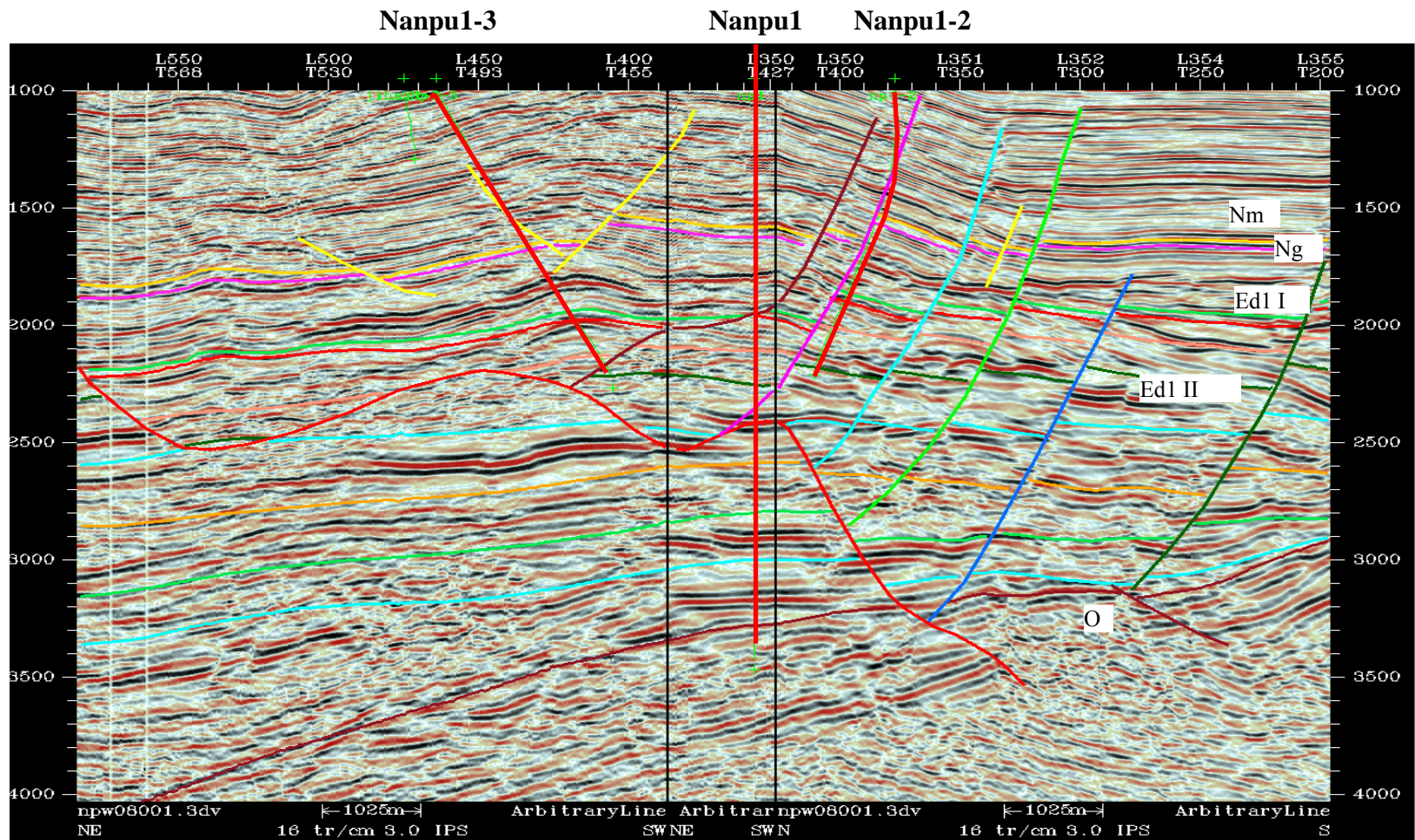
Borehole testing in the Ordovician (4035.19-4215.1 m) obtained daily flow of 700 m³ oil and 160×10³ m³ gas (25.4 mm bean choke)

Jidong Nanpu Oil Field: Structural Cross Section

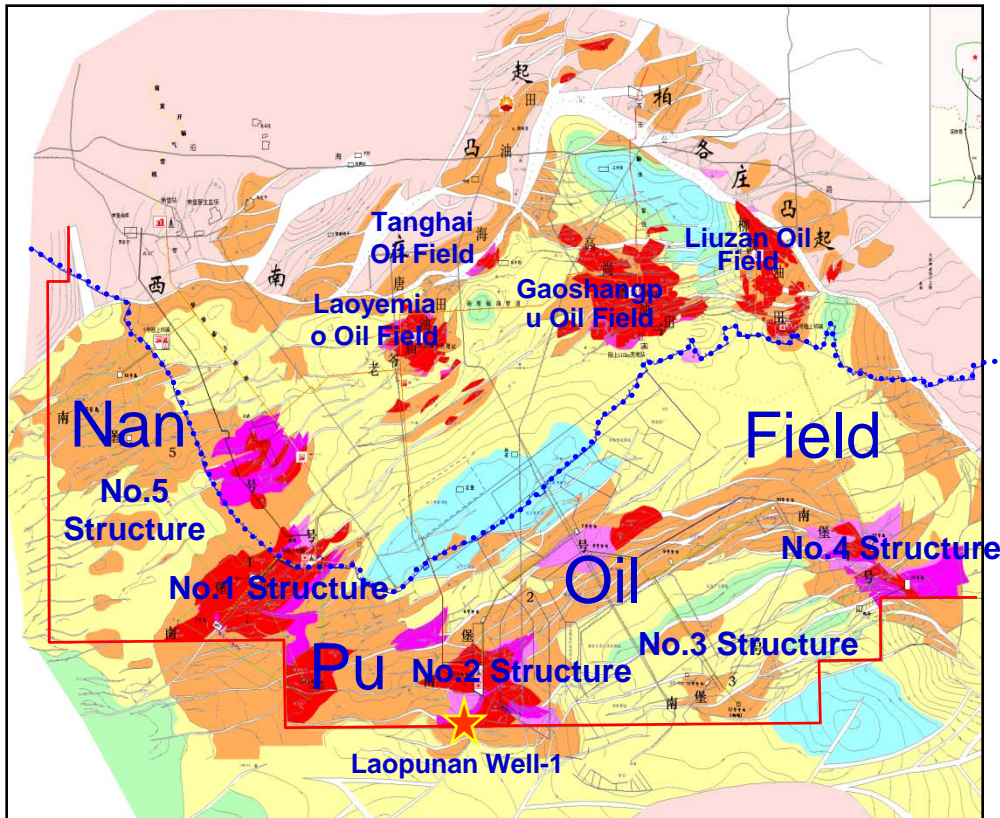


- **Structural trap**
- **Pay zone: 1800-2800 m**
- **Porosity: 25-32%; Permeability: 300-3000 md**
- **Oil Density: 0.82-0.84 g/cm³**

Jidong Nanpu Oil Field: Seismic Cross Section



Nanpu Oil Field: Exploration Results



➤ Four oil-bearing structures discovered

➤ 1.18 BT of oil equivalent reserves in place confirmed

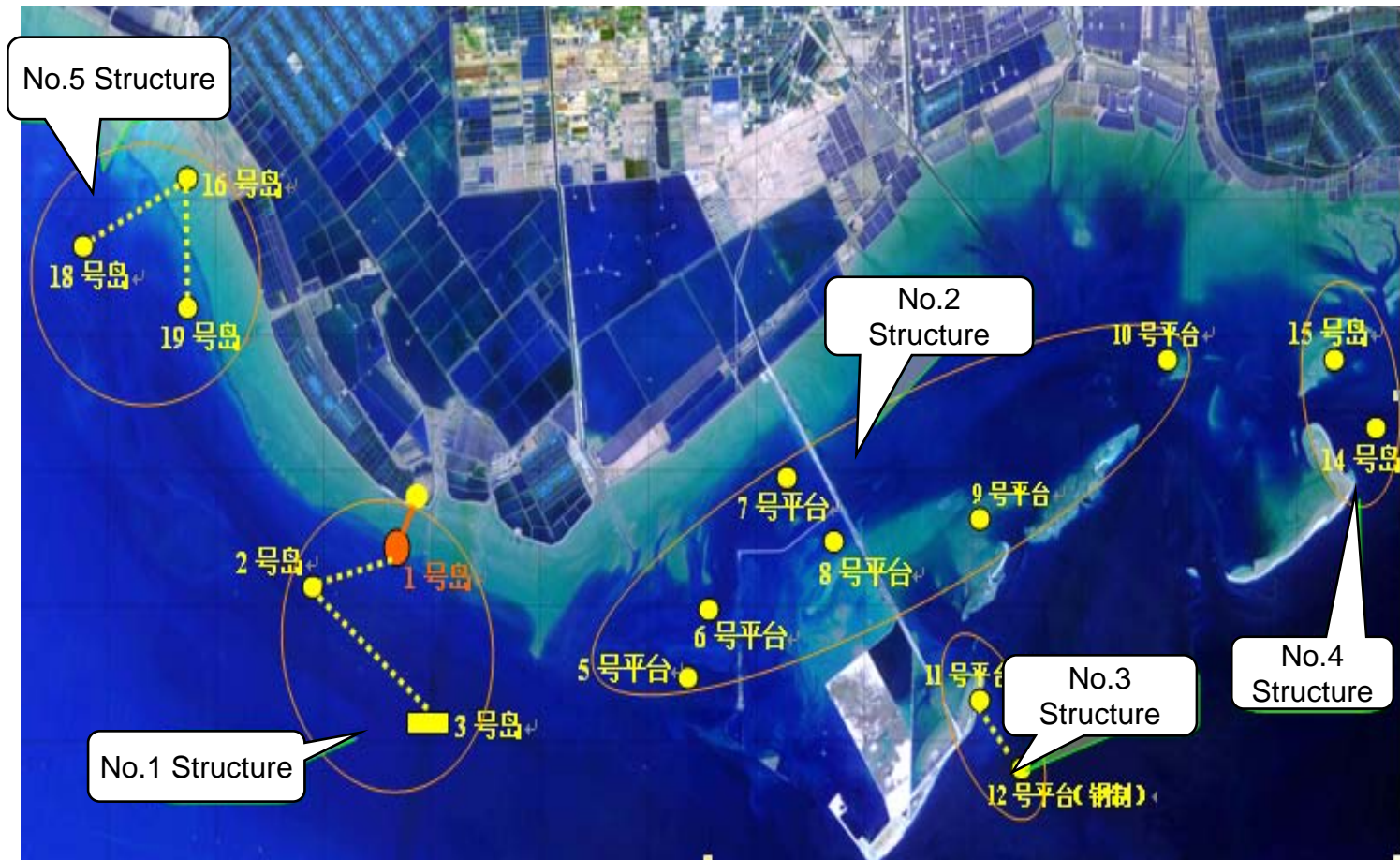
- Proven: 445 MT

- Probable: 336 MT

- Possible: 303 MT

- Dissolved gas: 120.85 BCM

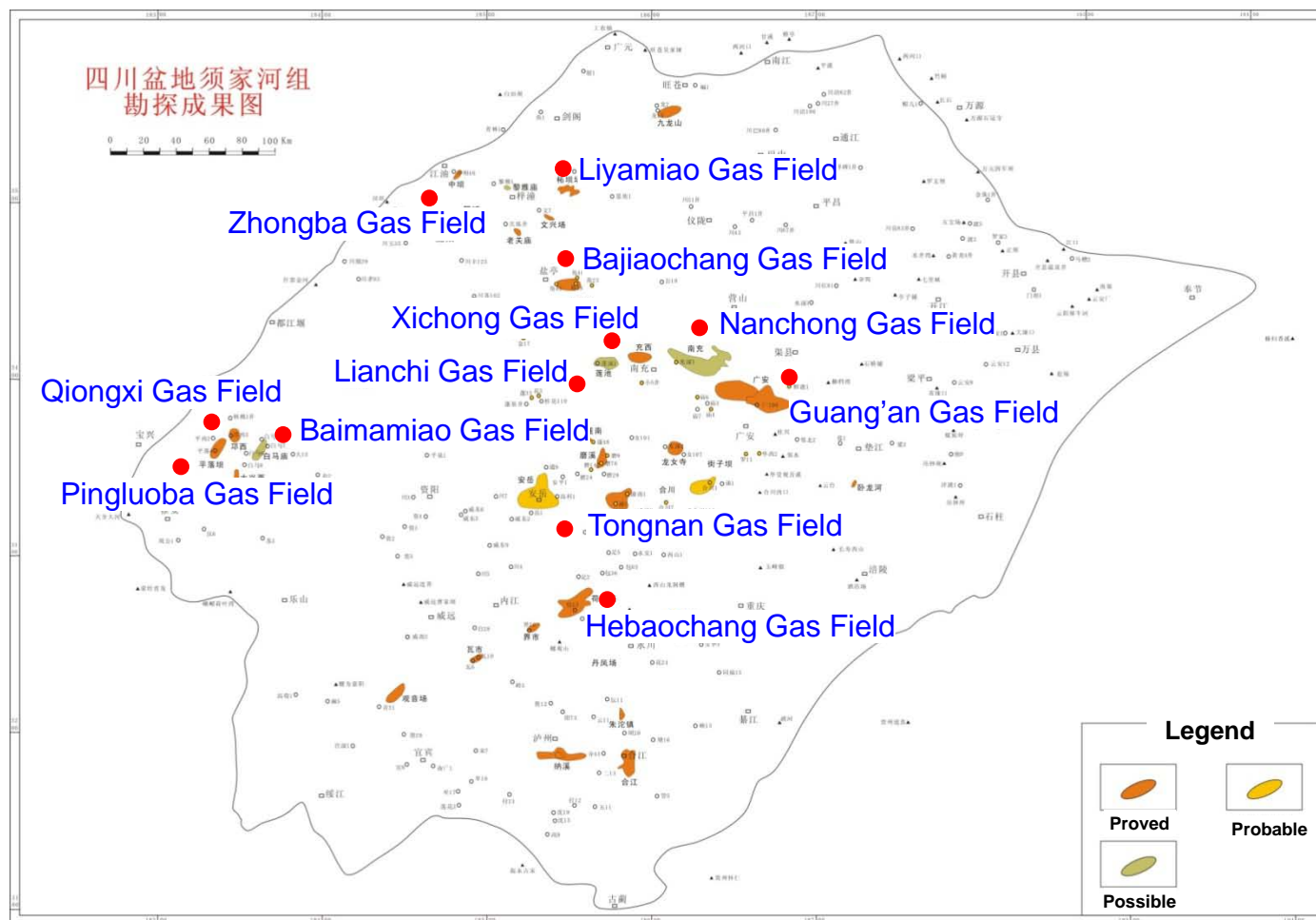
Nanpu Oil Field: Satellite View





② Large-Scale Tight-sands Gas Field - Xujaiahe Formation, Sichuan Basin

Background of Xujaiahe Formation Gas Fields



Triassic Xujaiahe Fm. gas fields are located mainly
in west and central Sichuan Basin

Exploration History of Xujiahe Formation, Sichuan Basin

- Two exploration stages:

- Structural trap (1956 – 2003): Bajiaochang, Moxi, Qiongxigong gas fields and a series of gas-bearing structures discovered

- Stratigraphic trap (since 2004): Guang'an, Hebaoshan, Tongnan, Hechuan gas fields discovered

- 33 gas-bearing stratigraphic pools confirmed in the Xujiahe Formation by 2007.

- The total reserves in place: ~ 451 BCM

- Proven: 263.4 BCM

- Probable: 80 BCM

- Possible: 107.6 BCM

- Resource base: 906.5 BCM

Xujiahe Formation Gas Fields in the Guang'an Region, Sichuan Basin

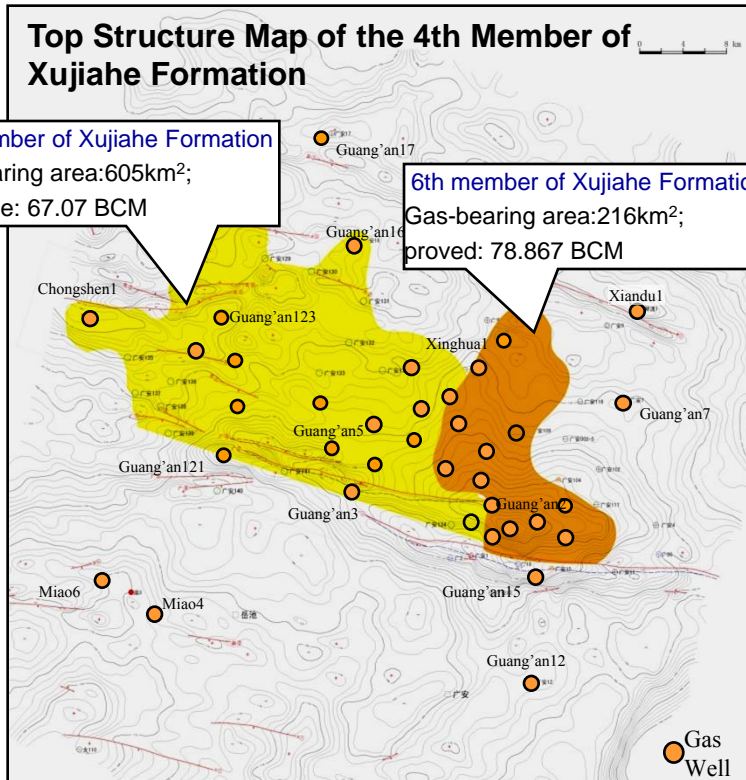
Top Structure Map of the 4th Member of Xujiahe Formation

4th member of Xujiahe Formation

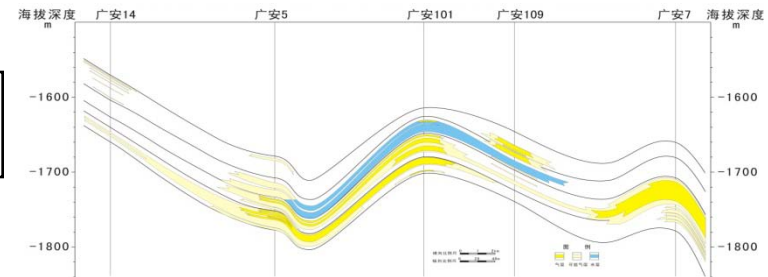
Gas-bearing area: 605 km²;
Probable: 67.07 BCM

6th member of Xujiahe Formation

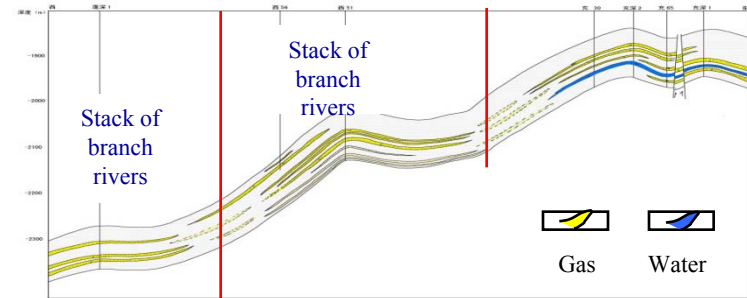
Gas-bearing area: 216 km²;
proved: 78.867 BCM



Cross Section of the 6th member of Xujiahe Formation



Correlation Figure of the 4th member of Xujiahe Formation



- Area of Guang'an Region 1000 km². Xujiahe Gas Field discovered by Guang'an 2 Well in 2005
- Triassic Xujiahe Formation clastic rocks and low permeable reservoirs. Reservoir thickness 25-40 m, single pay 5-15 m, Porosity 6-10%, Permeability 1-10 md
- Large scale structural-stratigraphic trap, with reserve abundance of 50-150×10⁶ m³/km²

Triassic Xujiache Gasfields in the Guang'an Region: production results

Sand fracturing and horizontal wells improved well production rate:

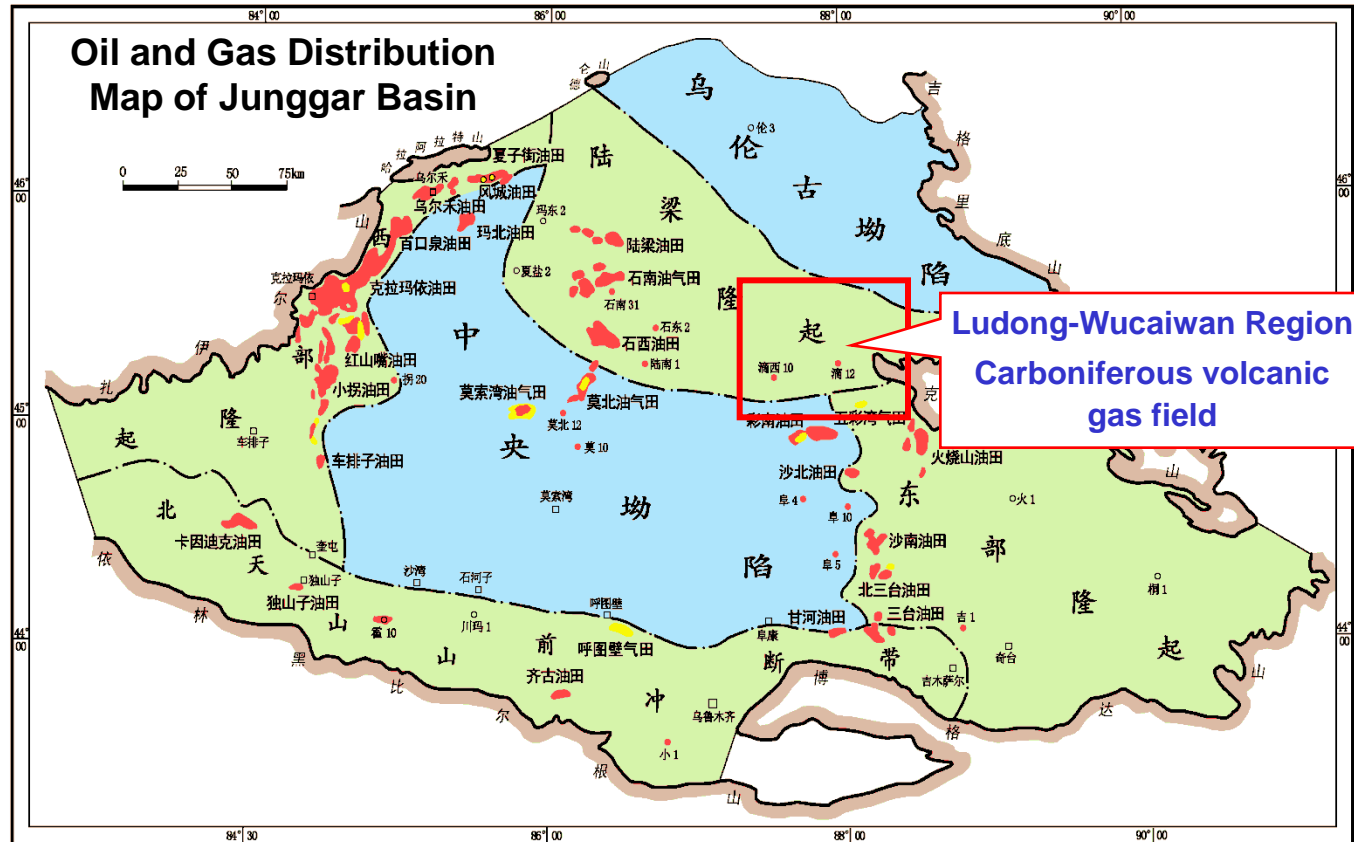
Before fracturing: low well production rate of $20 \times 10^3 \text{ m}^3$ daily

After fracturing: well production rate of $60\text{-}150 \times 10^3 \text{ m}^3$ daily

Well No.	Proppant (M ³)	Total liquid (m ³)	Pump pressure (MPa)	Displacement (m ³ /min)	Injection method	Production contrast (10 ³ m ³ /d)	
						Productio n before fracturing	Production after fracturing
Guang'an002-38	70	397.85	36/28	3.5-3.8	tubing	low	60.7
Guang'an002-35	100.5	709.83	32.5/29.6	3.5	tubing	21.9	174.6
Guang'an002-31	101.6	719.5	41.9/35.7	3.7	tubing	0.4	69.0
Guang'an002-21	100	730.91			tubing	10.4	35 (Est.)



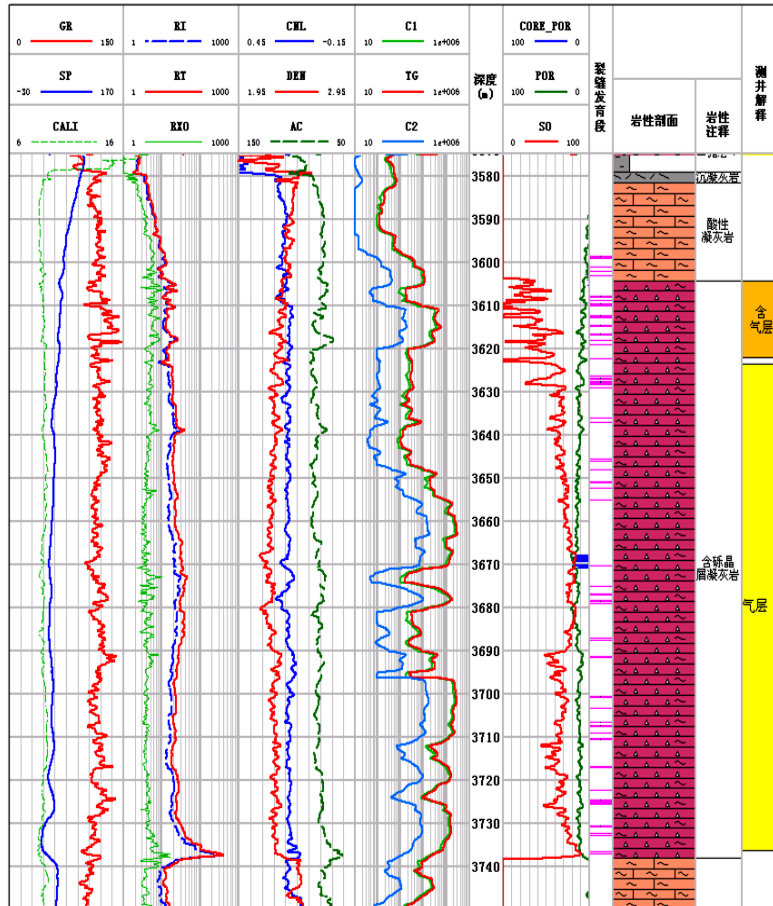
③ Volcanic Gas Field - Carboniferous in Junggar Basin



- Located in NE Junggar Basin, with an area of $22 \times 10^3 \text{ km}^2$
- Gravity-magnetic-seismic survey indicated a favorable area of about 2358 km^2 for the volcanic reservoirs, with 865 BCM of estimated gas resource

Significant Breakthrough in the Dixi-14 Well (2006)

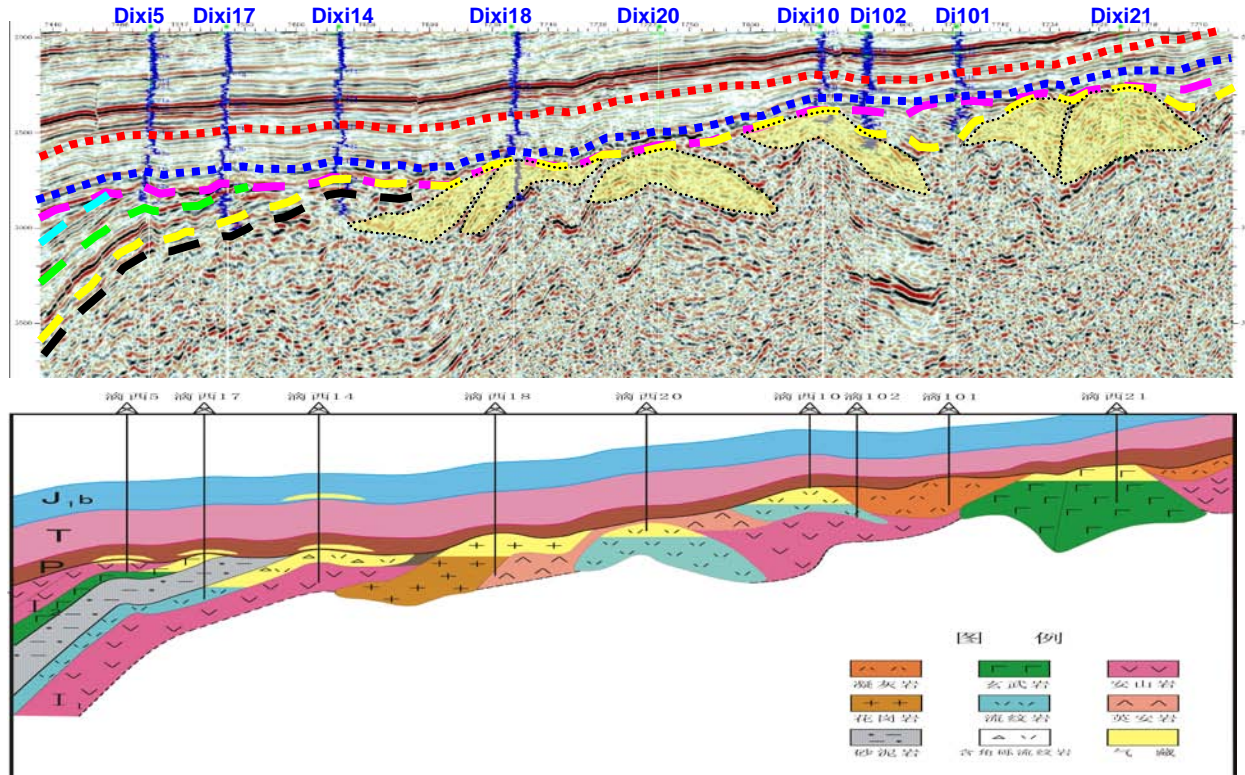
Comprehensive Log Interpretation of the Carboniferous Section



Test Result

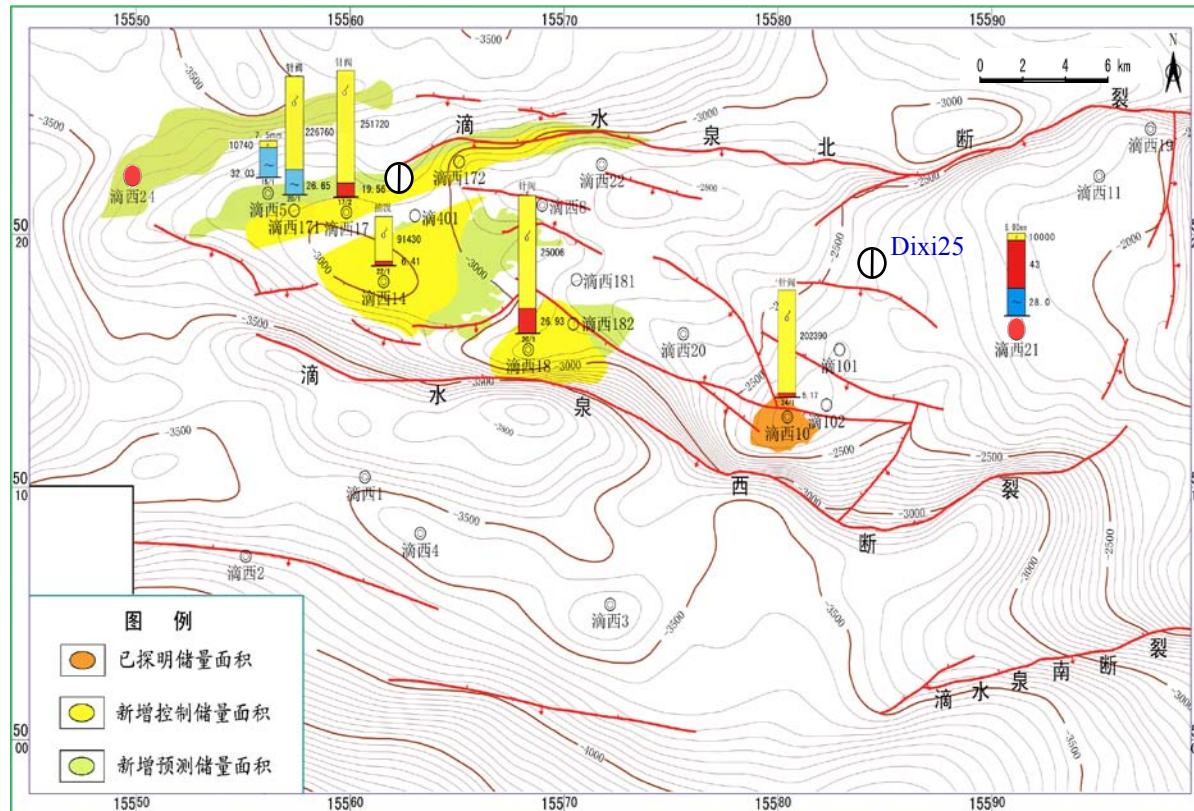
Layer	Test Section (m)	Oil Production (tons/d)	Gas Production (m ³ /d)
C	3652~3674	15.72	122490

Carboniferous Volcanic Gas Reservoirs in the Junggar Basin



- Stratigraphic and unconformity gas reservoir, with pay zone in the 3000-3800m interval
- Eruptive and effusive facies reservoirs, dominated by basalt, andesite, breccia and granite
- Reservoir thickness 20-320 m, fractured-porous dual-media, porosity 10-14.6% and permeability 5-21md

Carboniferous Volcanic Gas Reservoirs in the Junggar Basin



- 16 of 42 wells drilled into the Carboniferous obtained commercial flow
- 3P reserves in place: 139.8 BCM
- A gas province with 300-500 BCM reserves in the Carboniferous



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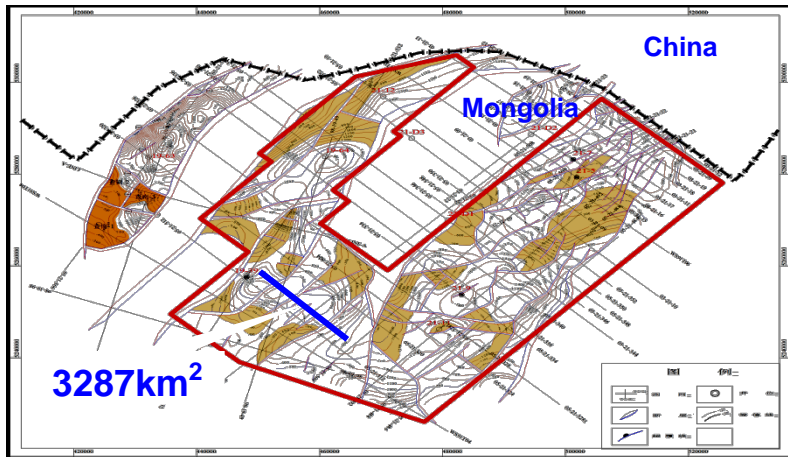
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① Large Scale Integral Deployment of 3D Seismic in Favorable Play

In 2007, PetroChina's 2D seismic 38243 km and 3D seismic 16082 km²

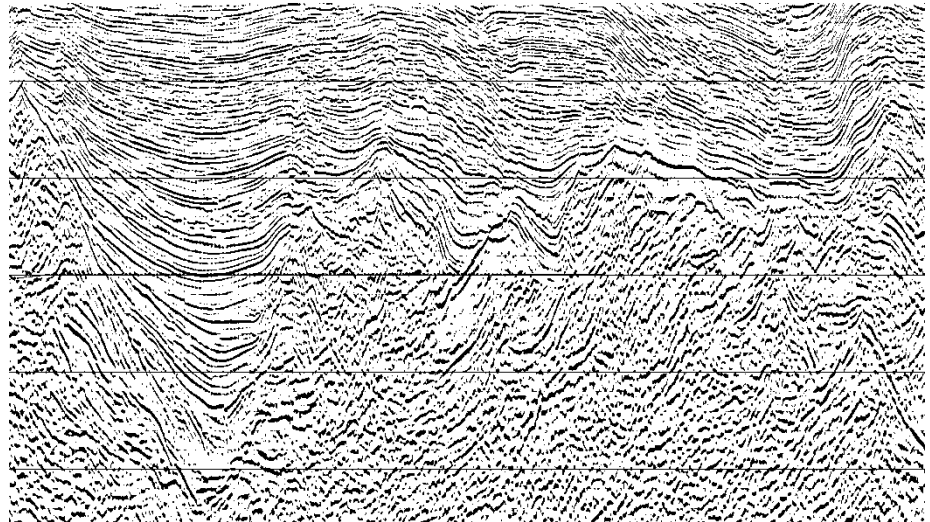


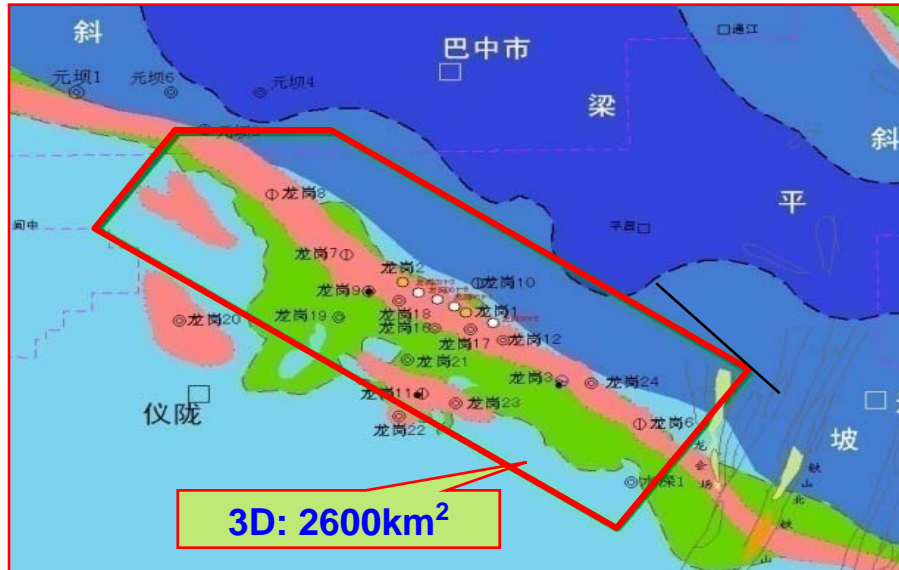
3287 km² of 3D seismic deployed integrally in the Bei'er Depression of Hailaer-Tamuchage Basin. 25*25m cell, with 60 fold times, the largest integral 3D seismic deployment at one time in China



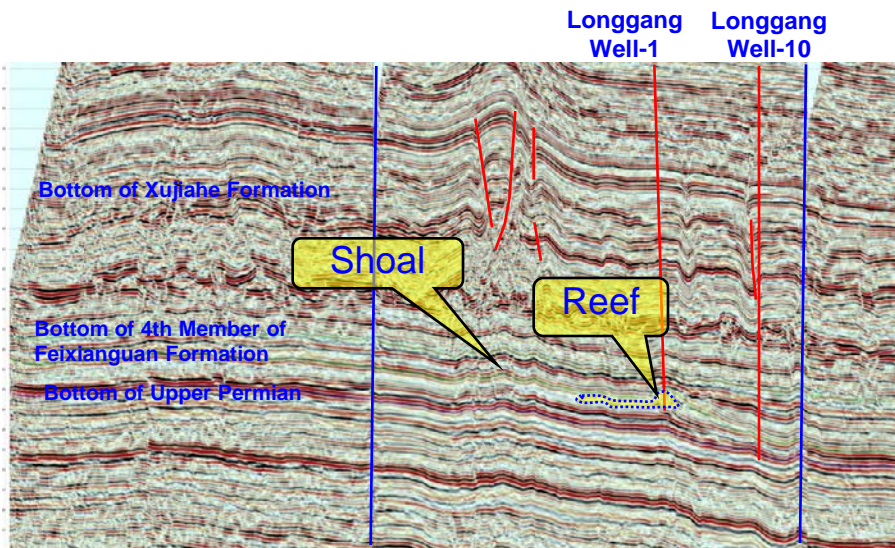
Deep Well Shooting
on grassland

Wave Detector
Embedding in Sands



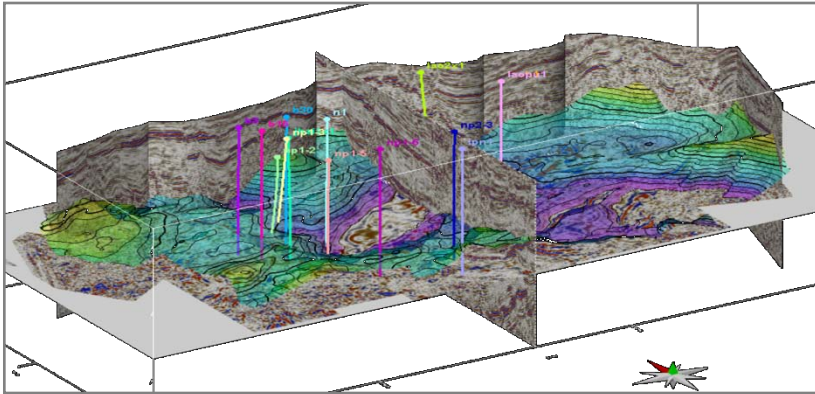


In Longgang Region of Sichuan Basin, 2600km² of 3D seismic deployed for reef-shoal composite. 25*25m cell, 70 fold times. The largest integral mountainous 3D seismic deployment at one time in China

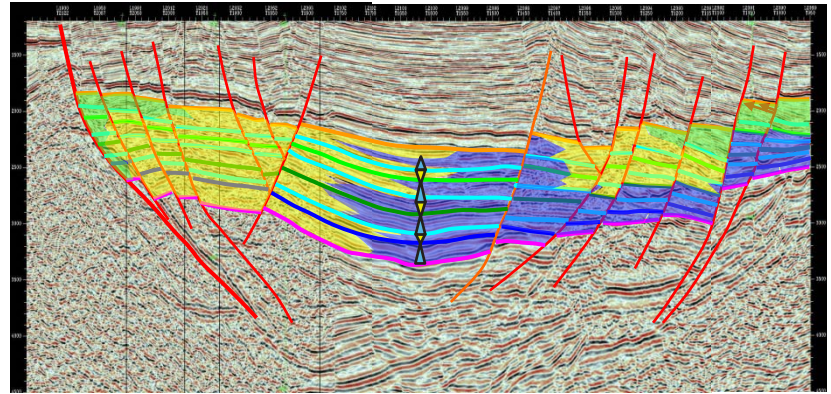




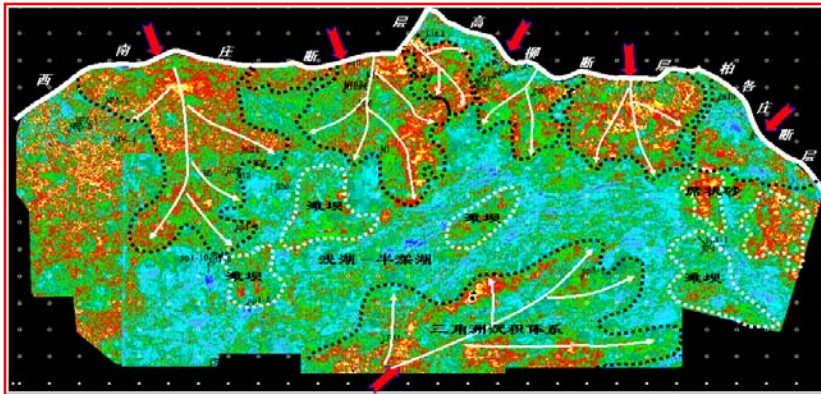
② Large Scale 3D Seismic Data Prestack Migration Processing and Interpreting



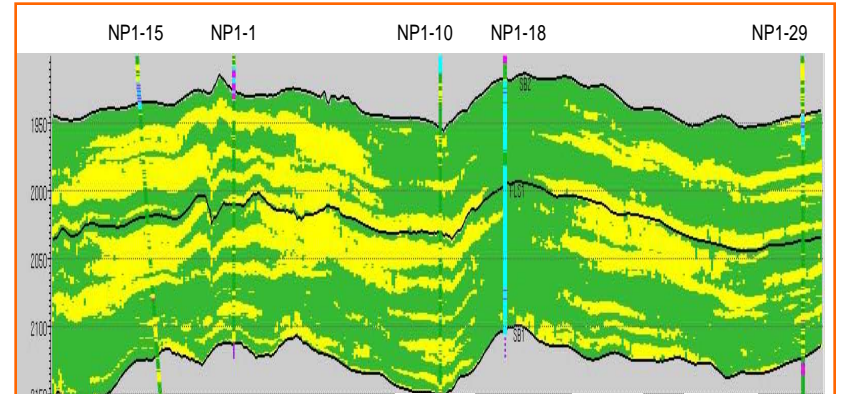
3D Seismic Data Merging Interpretation



Non-marine Sequence Stratigraphic Analysis

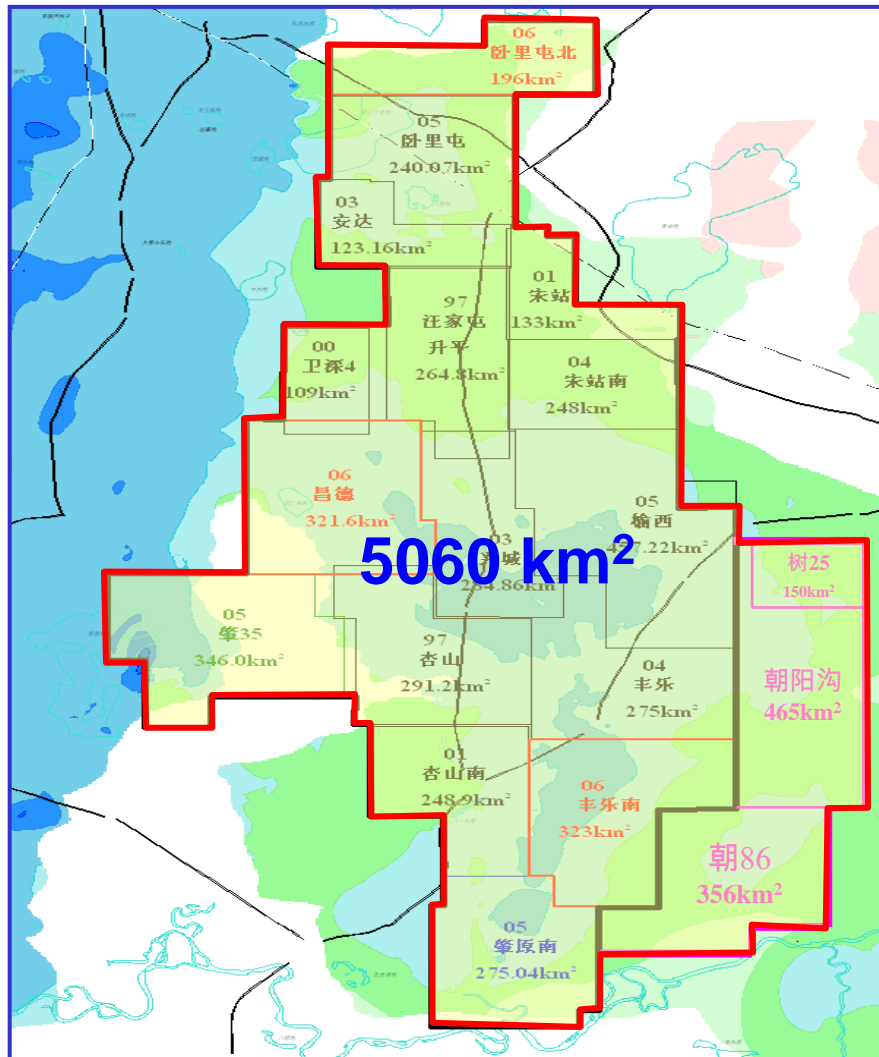


Seismic Attribute Analysis



Reservoir Inversion

3D Seismic Data Merging Processing and Interpreting in Songliao Basin



➤ In the past two years, PetroChina carried-out 3D seismic prestack time migration processing and interpreting in 29 blocks, 12 of which have area larger than 1000 km²

➤ Changjiaweizi, Songliao Basin, is the largest block, with an area of 5,060 km²

Conclusions

- The oil reserves and annual production in China increase steadily, with significant gas discoveries in the past few years
- There are still large remaining petroleum resources in the Chinese sedimentary basins
- The most recent giant discoveries were made mainly in stratigraphic traps
- Improved 3-D seismic technology has been largely responsible for these exploration breakthroughs



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Thank you!

