



中国石油大学(北京)

CO₂ Storage and Enhanced Oil Recovery in Jilin Oil Field

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Australia



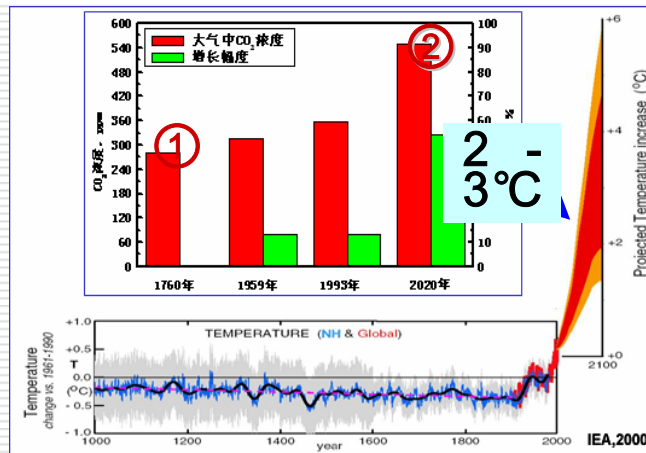
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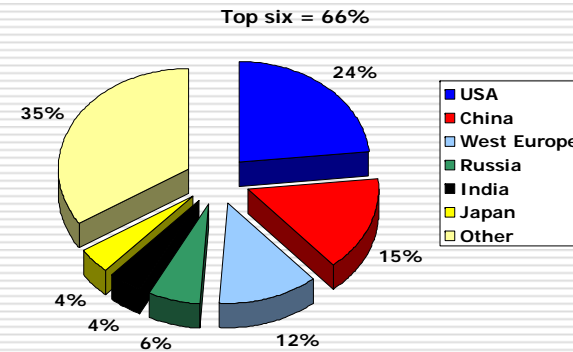


1. Background

- 1.Reduction of Green House Gas Emission---A topic which concerned around the world nowadays. Carbon Capture and Storage(CCS) is one of the most important technology.
2. Chinese Government Concerns Greatly about Reduction of CO₂ Emission and Utilization of It as Resources



Biggest Emitters 2000-2025



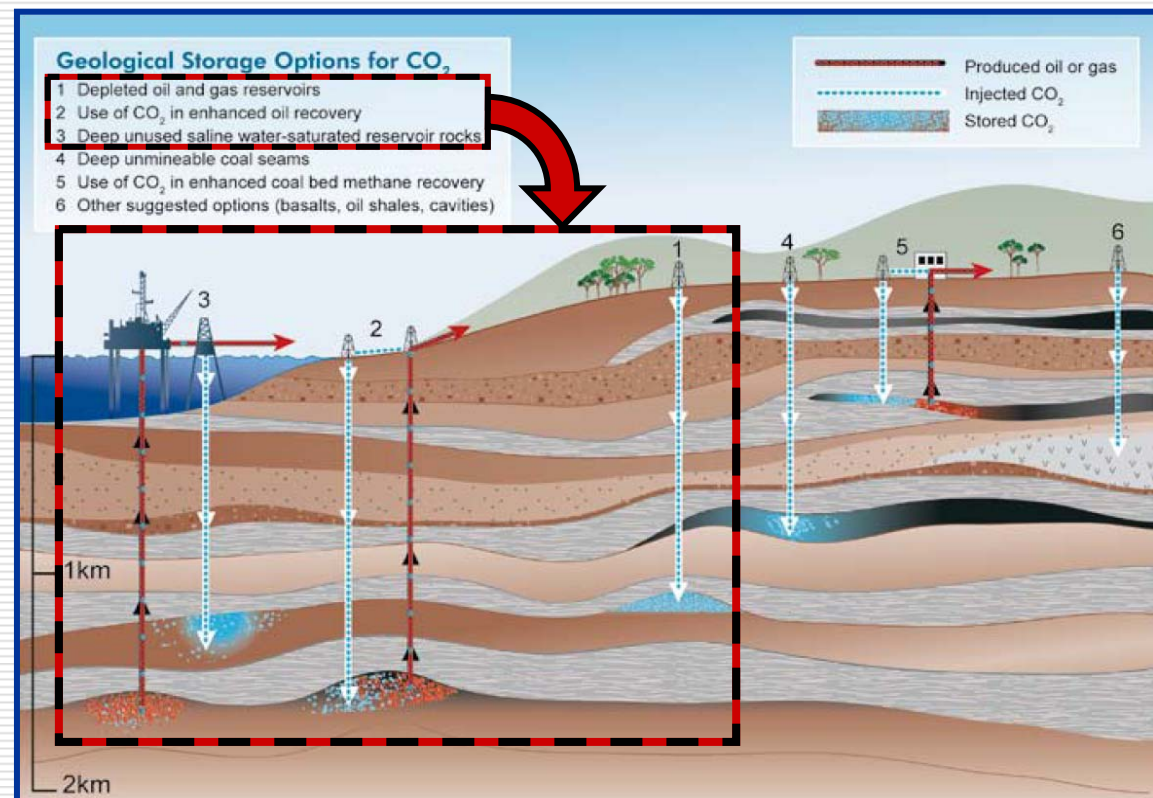
Cumulative CO₂ Emissions 2000-2025, EIA, IEA 2002



1. Background

3. CO₂ Storage and EOR in China

- Oil&Gas Reservoir, Subsurface Salaquifer, coal bed, **ideal Place for CO₂ Storage**
- **923 billion tons** of CO₂ can be stored in reservoir, which is **45%** of global cumulative emission in 2050.





2. Basic Research

“ Utilizing Greenhouse Gas as Resource in EOR and Storing It Underground” (973)

- **In 2006, a 973 project (The National Basic Research Program) named ‘Research for Utilizing Greenhouse Gas as Resource in EOR and Storing It Underground ’ was authorized by China Ministry of Science and Technology.**
 - **Chief Scientist: Prof. Shen Pinpin**
 - **8 sub-projects is included.**
 - **Basic Research**
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2. Basic Research

- ❑ Project 1 Standard stipulation and potential evaluation for CO₂ storage that meets China geologic characteristic, PetroChina
 - ❑ Project 2 Geologic theory of CO₂ subsurface storage, Chinese Academic of Sciences
 - ❑ Project 3 Theory and technology of monitoring and front predicting during CO₂ storage process, Beijing University
 - ❑ Project 4 Research on phase theory of multiphase and multicomponent during CO₂ flooding process, PetroChina
 - ❑ Project 5 Nonlinearity flow mechanism and law of multiphase and multicomponent during CO₂ flooding process, China University of Petroleum
 - ❑ Project 6 Principle of O₂/CO₂ circulating combustion for coal and mechanism of synergetic removal pollutant, Huazhong University of Science and technology
 - ❑ Project 7 Theory and technology of CO₂ separation and concentration from industrial gas, Qinghua University
 - ❑ Project 8 Theory and method of engineering for CO₂ corrosion prevention and antiscale, Jilin Oil field
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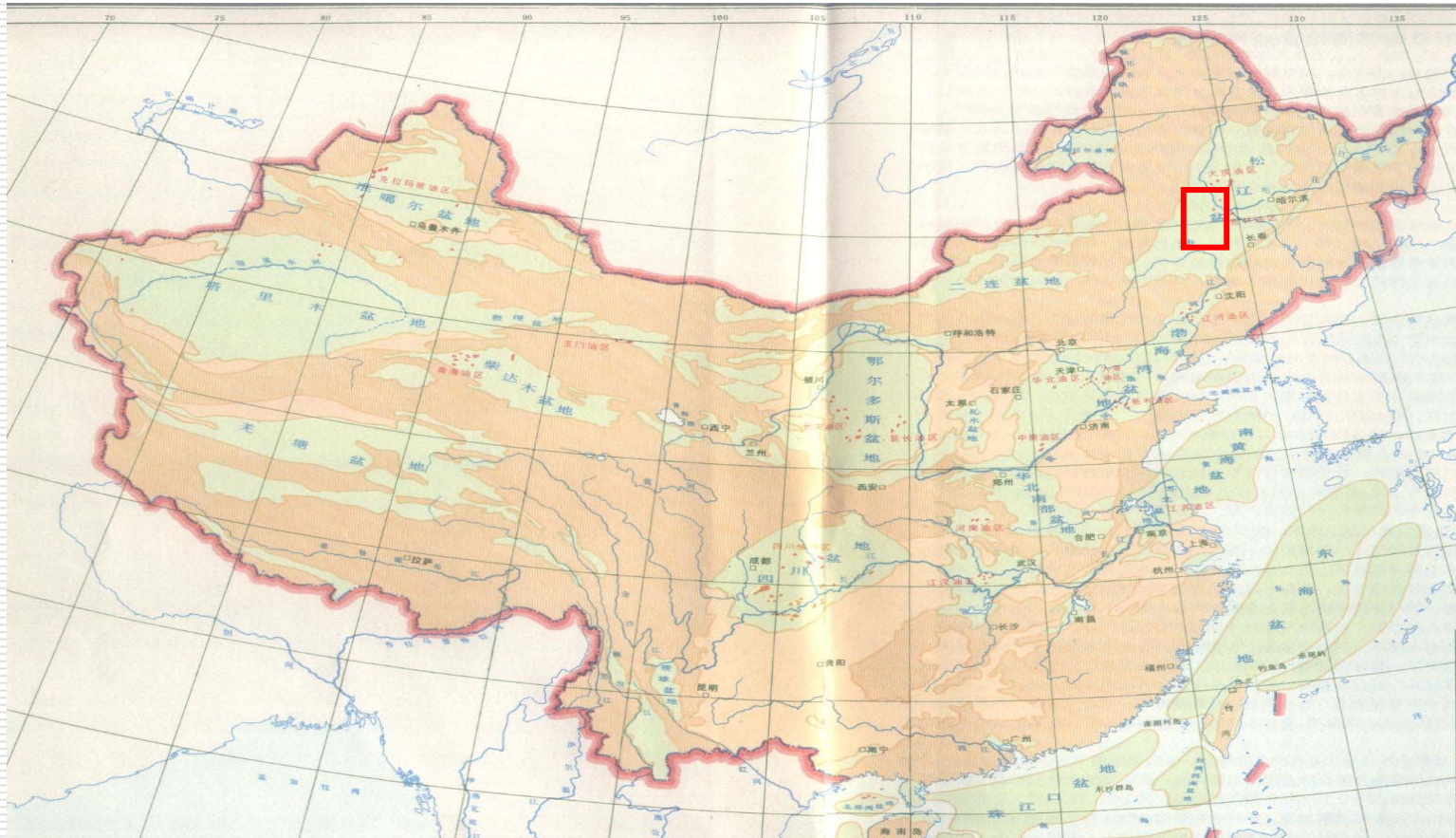
3. Pilot Test in Jilin Oilfield

- **“CO₂ Storage and Enhanced Oil Recovery in Jilin Oil Field”
Major Science & Technology Research Project and Key Pilot Test
were conducted by PetroChina**

 - **In 2007, a key science& technology research project named ‘Utilizing
Greenhouse Gas as Resource and Storing it Underground’ was established
by PetroChina.**

 - **In 2007, a key pilot test named ‘Pilot Test of CO₂ EOR and Storage in
Jilin Oil Field’ was established by PetroChina**
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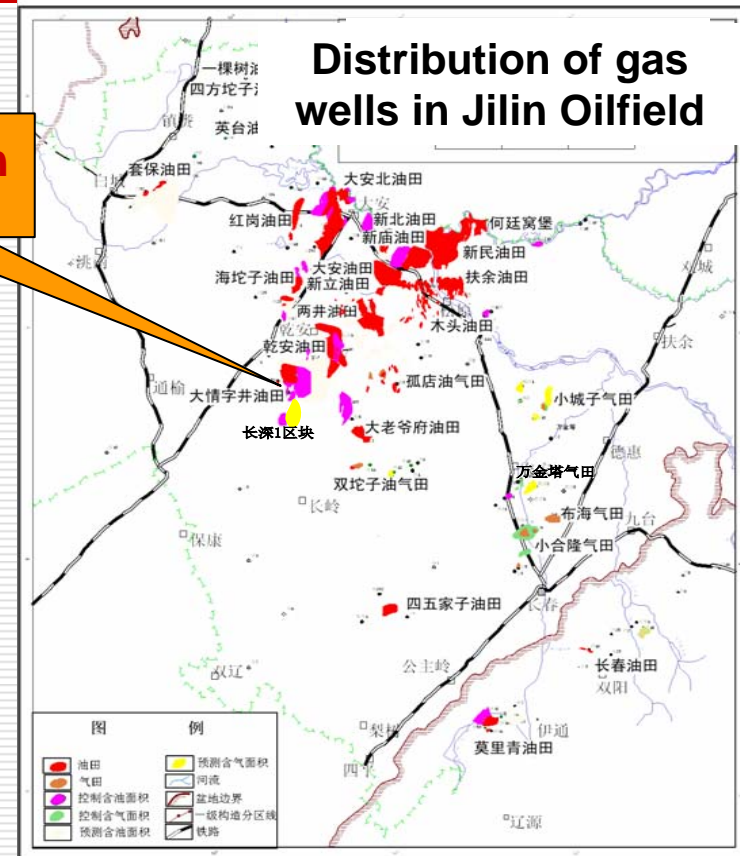
3. Pilot Test in Jilin Oilfield



3. Pilot Test in Jilin Oilfield

- Natural Source of CO₂ is mainly from natural gas (the content is 22.5%)
- Reserve of CO₂ is 12.5billion m3.

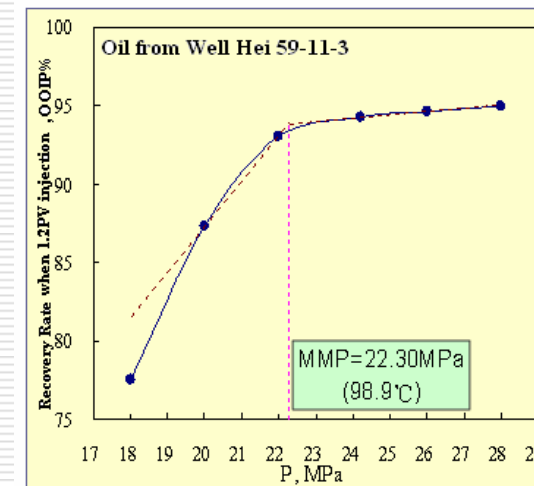
Chang Chun
gas field



3. Pilot Test in Jilin Oilfield

The condition of reservoir for miscible and immiscible flooding in Jilin Oil Field

- The condition for miscible flooding of typical reservoir in Jilin Oil Field was obtained.
(Recovery rate can be enhanced by 10%~20%)
- Miscible flooding condition test result:
Miscible flooding can be achieved in block Hei-59 and Hei-79.

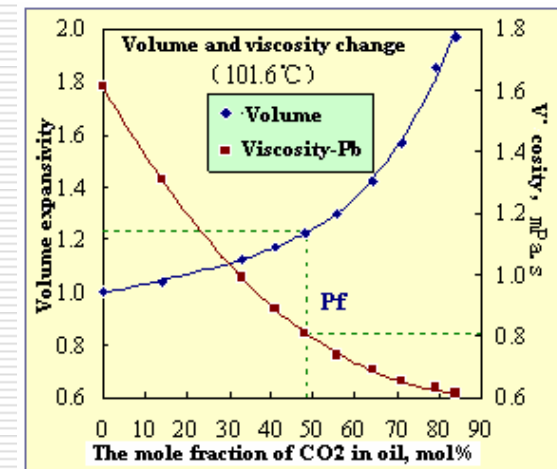


Source for oil sample	Hong8 7-2	Qian'an	Hei-59	Hei-79
Pressure ,MPa	21.20	18.50	24.20	23.10
Temperature ,℃	101.6	76.0	98.9	97.3
MMP(Slim-tube test),MPa	27.45	20.20	22.30	22.10
Conclusion	immiscible	immiscible	miscible	miscible

3. Pilot Test in Jilin Oilfield

The condition of reservoir for miscible and immiscible flooding in Jilin Oil Field

- The condition for immiscible flooding of reservoir in Jilin Oil Field was obtained.(Recovery rate can be enhanced by 5%~10%)
- On the condition of reservoir, CO₂ have strong effect of volume expansion and viscosity reduction for oil from Hei59, Hei79, Hong87-2 and Qian'an formation. The CO₂ immiscible flooding is also beneficial for EOR.



Source	Pressure(M Pa)	Temperature(°C)	Solubility of CO ₂ (mol/%)	Volume expansion	Viscosity Reduction(%)
Hong87-2	21.20	101.6	48.30	1.23	56.70
Qian'an	18.50	76.0	45.90	1.27	58.40
Hei59	24.20	98.9	63.96	1.47	63.20
Hei79	23.11	97.3	63.58	1.41	59.62

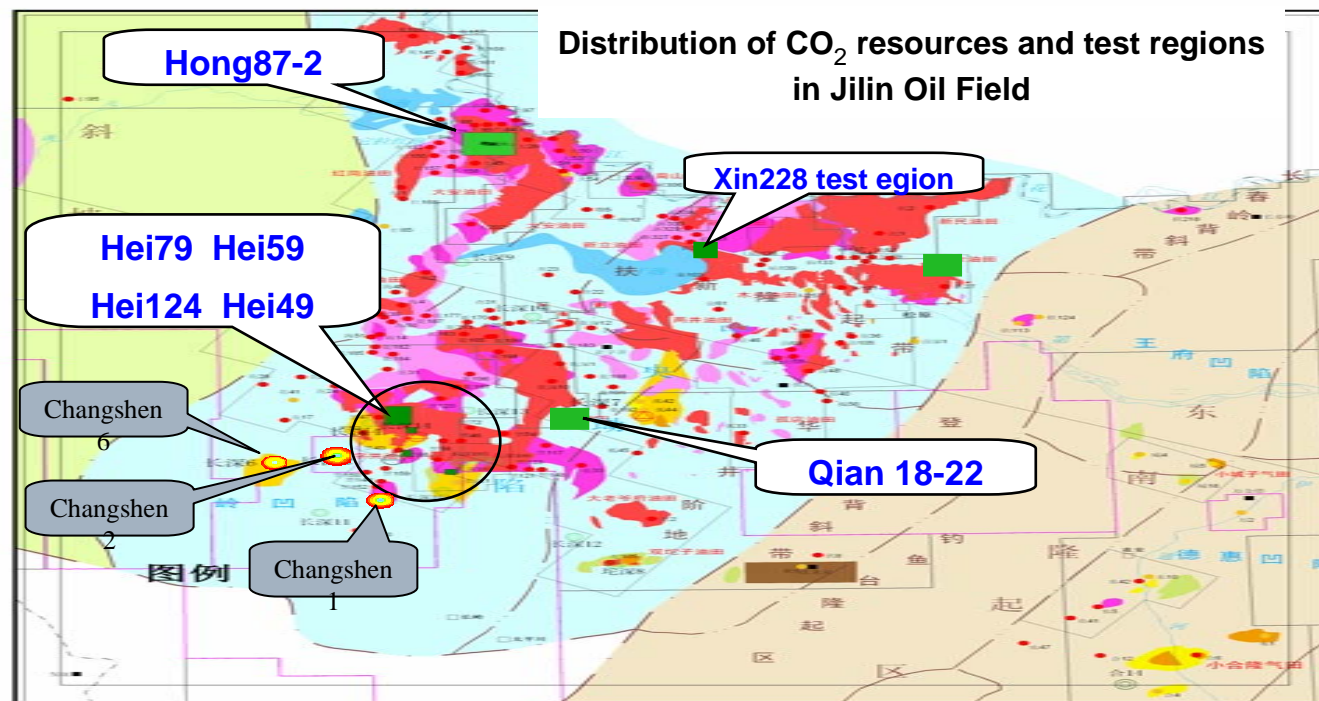
3. Pilot Test in Jilin Oilfield

Pilot test program of block Hei79, Hei59, Hong87-2, Qian'an were formulated.

Pilot test program of miscible flooding in Hei79 and Hei59

Immiscible flooding pilot test program in Hong 87-2

Pilot test program in Qian'an





3. Pilot Test in Jilin Oilfield

Pilot test of CO₂ injection

Pilot Test for Liquified CO₂ Injection --- Xin 228 Block of Xinli Oilfield

- Xin 228 block is a part of Xinli structure and is located in the north of it. The angle of structure dip is 1.06 degree. The average effective thickness of reservoir is 8.93 m, average permeability of reservoir is 0.35 mD, porosity is 12.38%, temperature is 66 °C

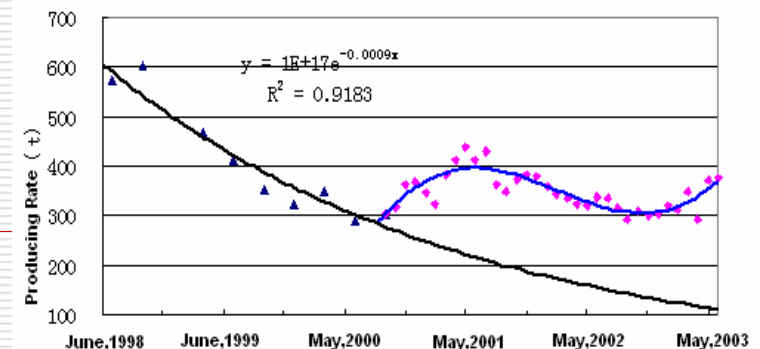
Test Result

- As of the end of June, 2003, 5121 tons of crude oil was cumulatively increased, with the injection/production ratio 1:4.28, corresponding to 3.2 tons of crude oil increased by each ton of CO₂.

The Effect of Well Group 54-4

Well	Date for action	Effect time (day)	Oil increased per day	Oil increased accumulative	Ratio for production enhancement	Remark
54-6	Oct.,2000	730	1.02	743.70	48.5	Work
56-4	Sep.,2000	560	0.34	190.00	24.2	Work
56-2	Oct.,2000	540	0.32	170.60	28.7	Work
52-4	Dec.,2000	323	0.11	34.00	11.7	Work
54-2	Nov.,2000	360	0.26	93.30	32.4	Watercut decline at first
52-6						Watercut decline at first
56-6	Feb.,2001	400	0.86	343.60	24.5	delay
52-2	Nov.,2001			77.80		
Total				1653.00		

Curve for decreasing of producing rate

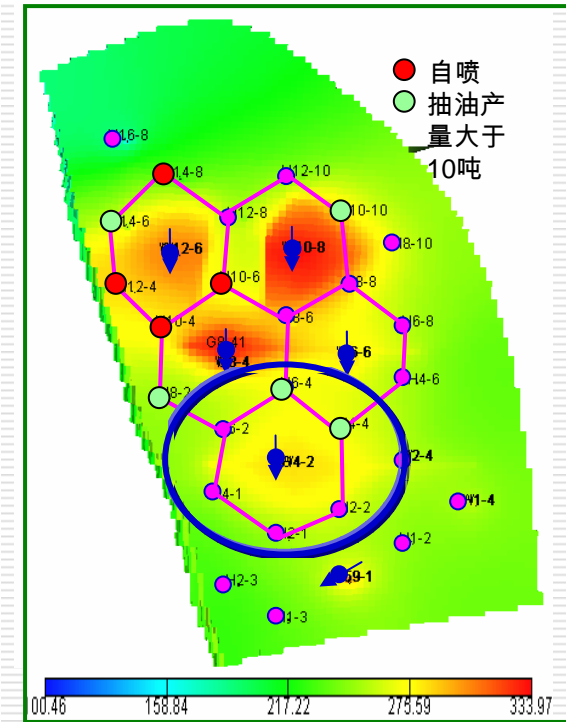
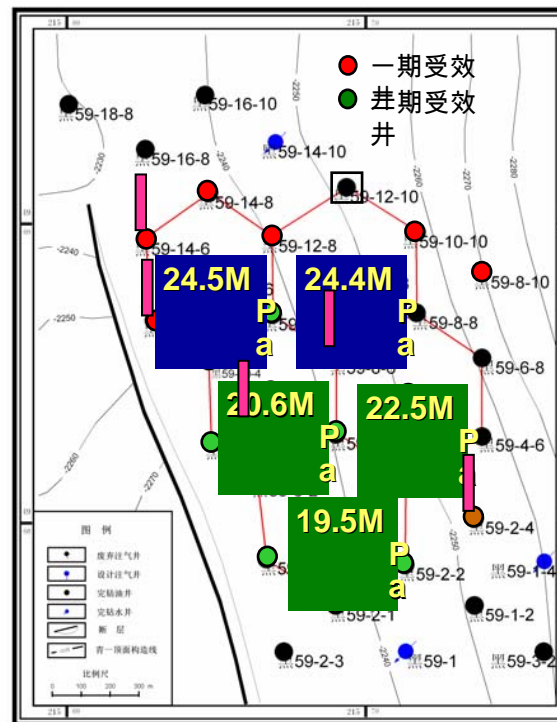




3. Pilot Test in Jilin Oilfield

Hei59 CO₂ Pilot test

- EOR layer: QING1 7,12,14 layer, average depth 2400 meter
- Well Pressure ≤ 40 MPa;
- CO₂ Injection : 30~40t/d
- Well groups: 5 well groups,(1inject well,6 product well),Total:5In.19Pr.,
- Liquid CO₂ continuous injection
- MMP: 22.1 MPa

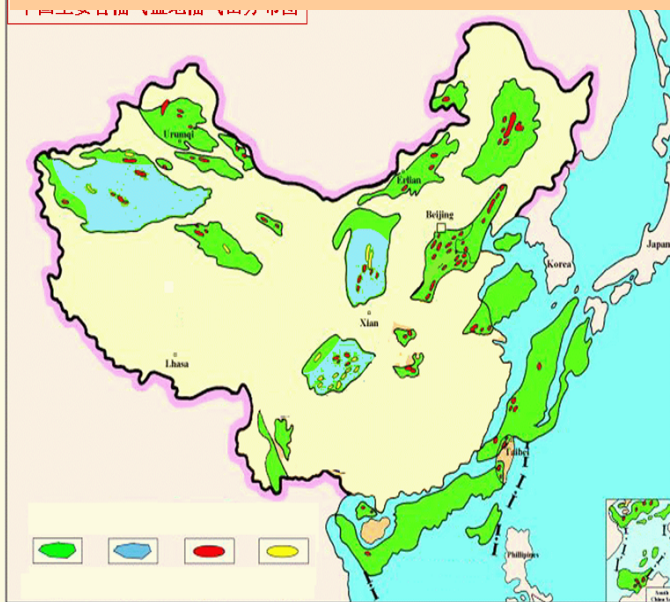




4. Opportunity

Low permeability reservoir account for a large percentage

Distribution of oil fields in China main oil and gas bearing basin



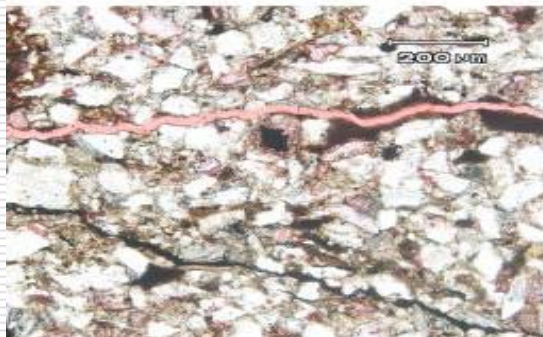
- 30% OOIP deposited in the low-permeability reservoirs in China.
- 2/3 undeveloped oil in place deposited in low-permeability reservoirs ($K < 10\text{mD}$).
- 95% oil in CNPC produced from waterflooding reservoirs.



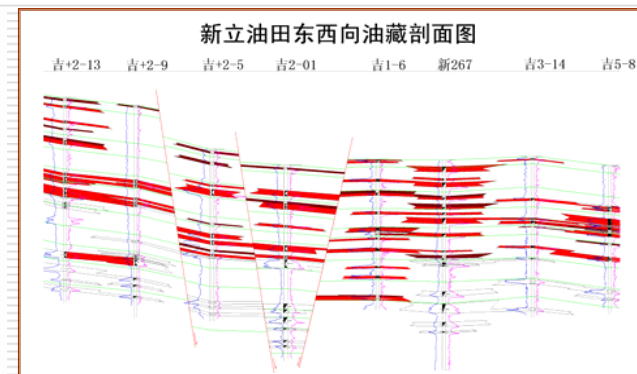
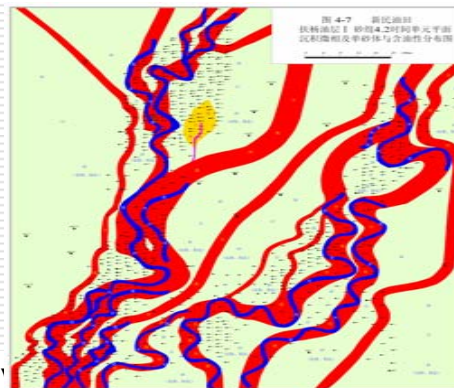
5. Challenge

Reservoir characteristics of low permeability reservoirs in China

- Small pore throat, low P&K, poor reservoir quality
- lithologic trap, poor reservoir continuity
- thin interbedded sandstone and mudstone
- variable reservoir thickness and physical properties
- well-developed micro-fracture
- strong heterogeneity
- higher water saturation



Micro-pore with fracture (thin section)



thin interbedded sandstone and mudstone



6.Cooperation

Oil Co.:

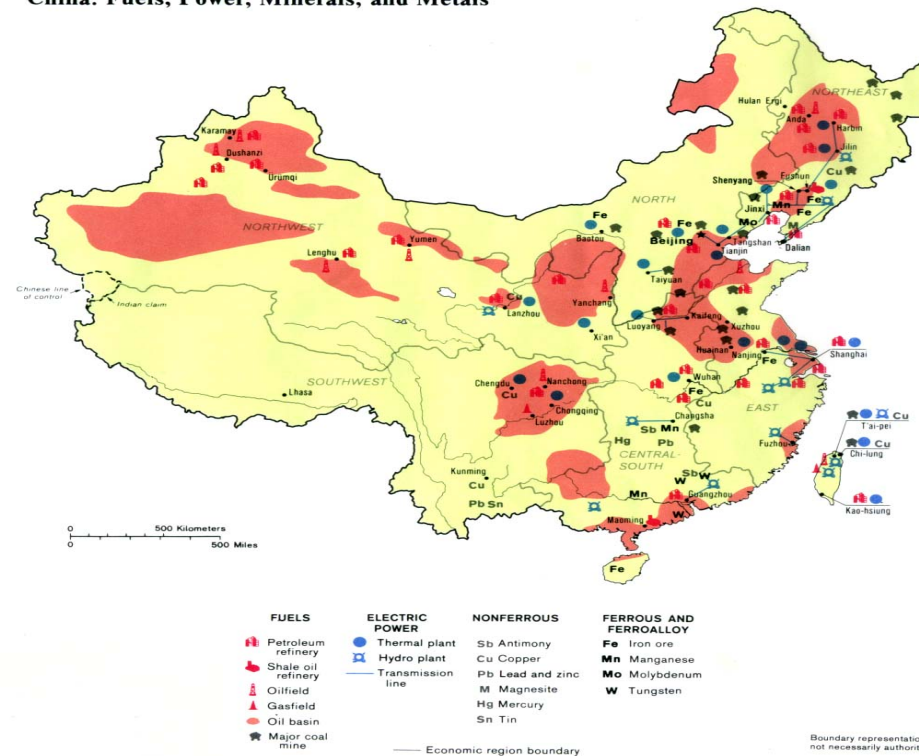
Power Co.:

New Mechanism?

CO₂ Tax?

CO₂ Price?

China: Fuels, Power, Minerals, and Metals





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6. Cooperation

International Cooperation: NEZC, COACH, STATRA, CAGS....CDM???





7. Conclusion

- ❑ China is a developing country. With the sense of responsibility, China has taken a series measures, such as conducting the national project of Research for Utilizing Greenhouse Gas as Resource in EOR and Storing It Underground.
 - ❑ In 2007, a major science & technology research project named 'CO₂ EOR and Storage Underground' and a key pilot test named 'CO₂ EOR and Storage Pilot Test in Jilin Oil Field' were established by PetroChina.
 - ❑ Petrochina will start new 'CO₂ EOR and Storage Underground' pilot test in Daqing and Changqing Oil field.
 - ❑ More Cooperation is needed to do in CO₂ storage and EOR.
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