



GCEP International Workshop August, 2005
Tsinghua University

CO₂ Sequestration potential in Coal Seams of China

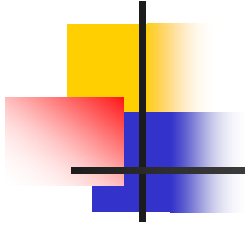
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China United Coalbed Methane Co., Ltd.
Beijing 100011



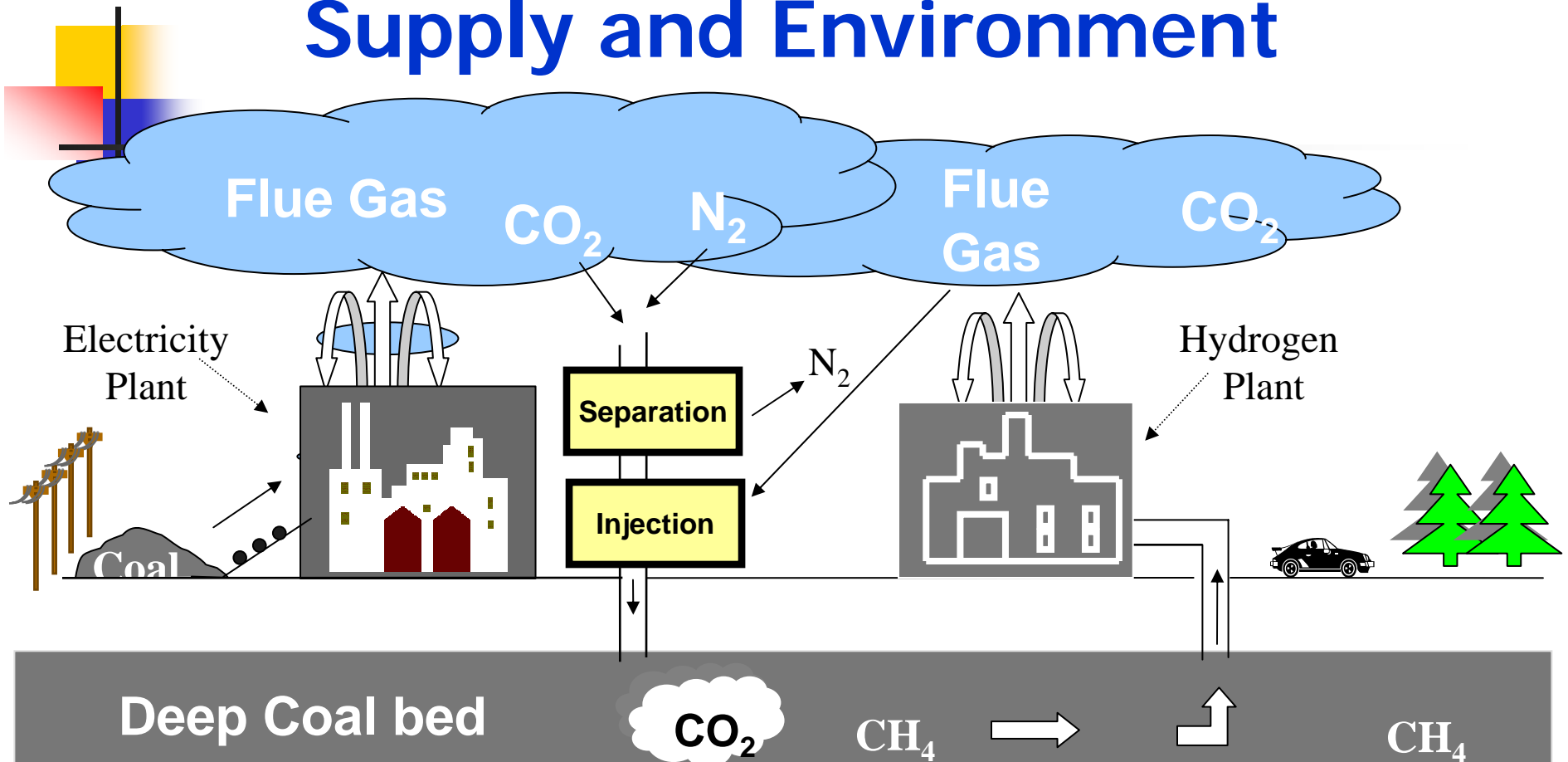
Outline of Presentation

- The enhanced coalbed methane (ECBM) and CO₂ Sequestration process
- Laboratory measurements of CO₂ / CH₄ adsorption
- Micro-pilot field test in south Qinshui basin
- CO₂ storage potential in coal seams in China



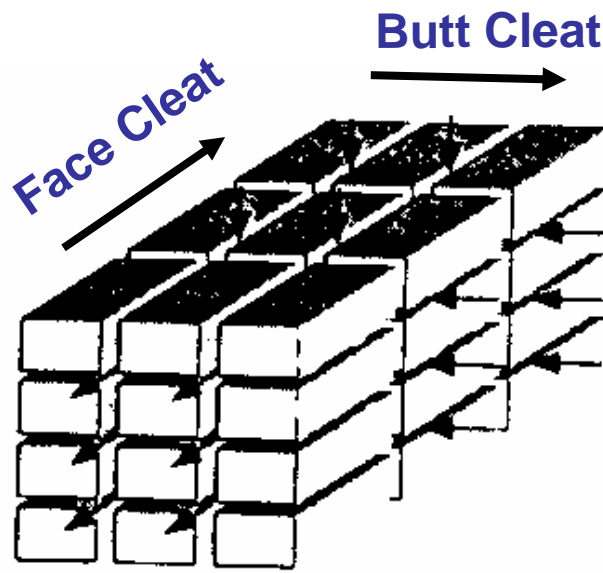
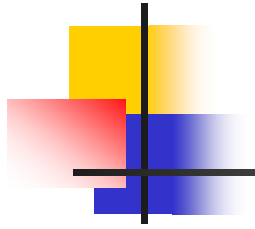
1 The enhanced coalbed methane (ECBM) and CO₂ Sequestration process

Opportunity to address both Gas Supply and Environment

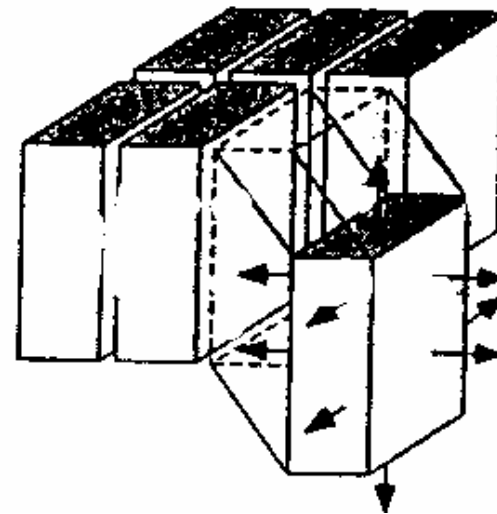


- Enhanced coalbed methane (ECBM) recovery
- Sequestration of CO₂

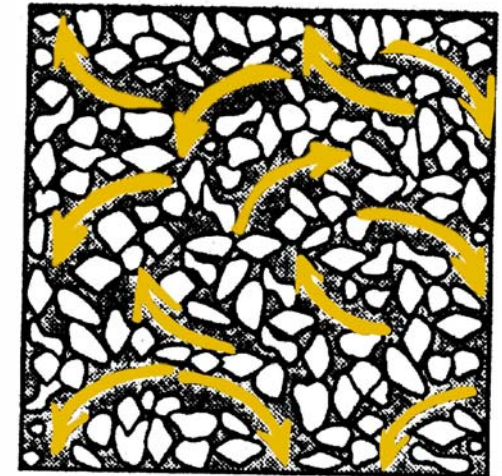
Process of Gas Transport in Coalbed Methane Reservoirs



1. Fluid Production from Natural Fractures



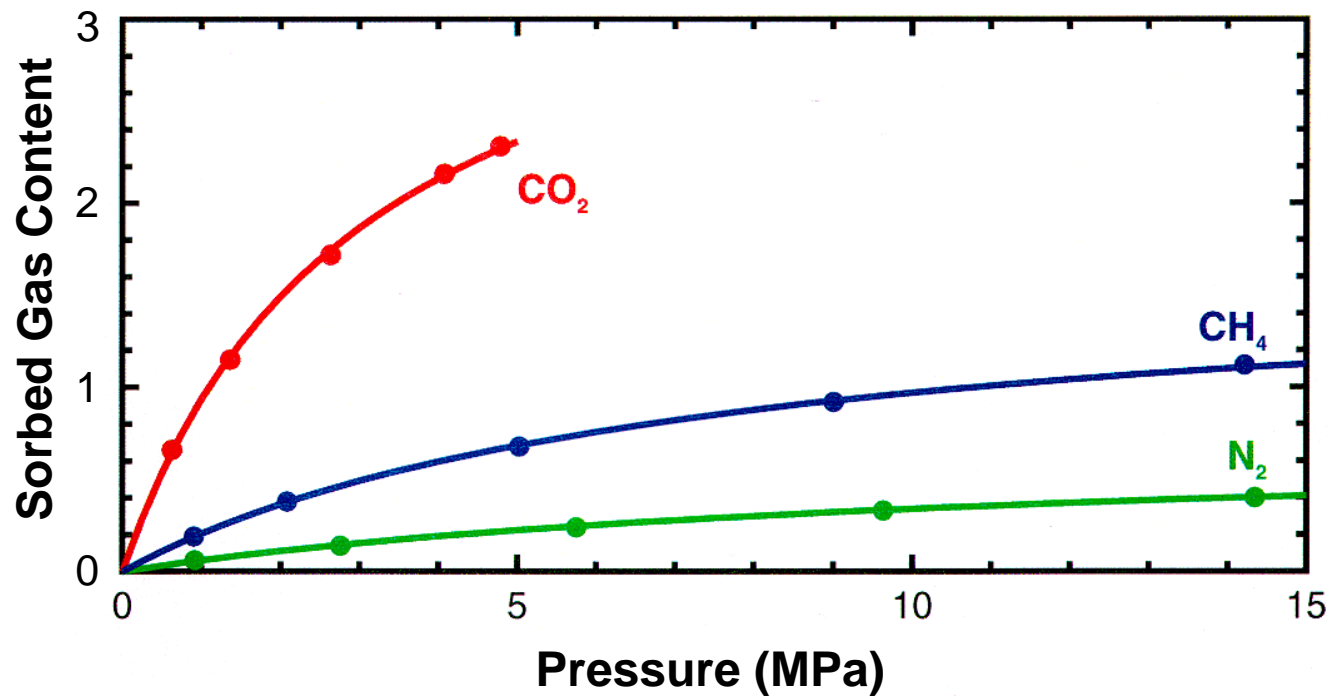
2. Gas Desorption from Cleat surfaces



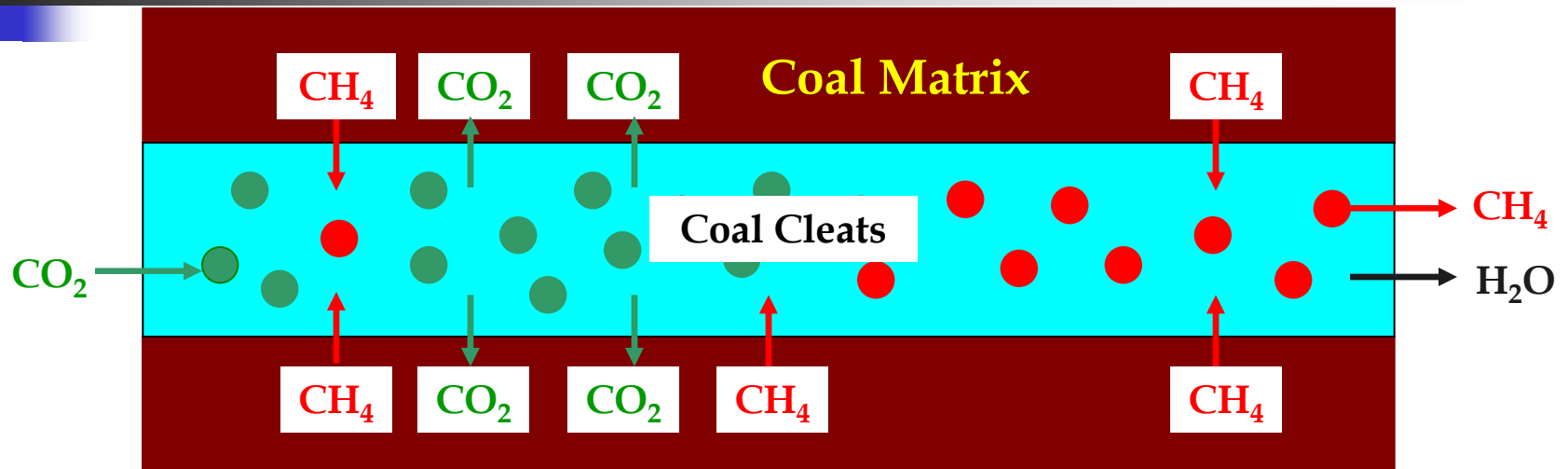
3. Molecular Diffusion through the coal matrix

Sorption Data for Different Pure Gases

Gas Sorption Isotherm

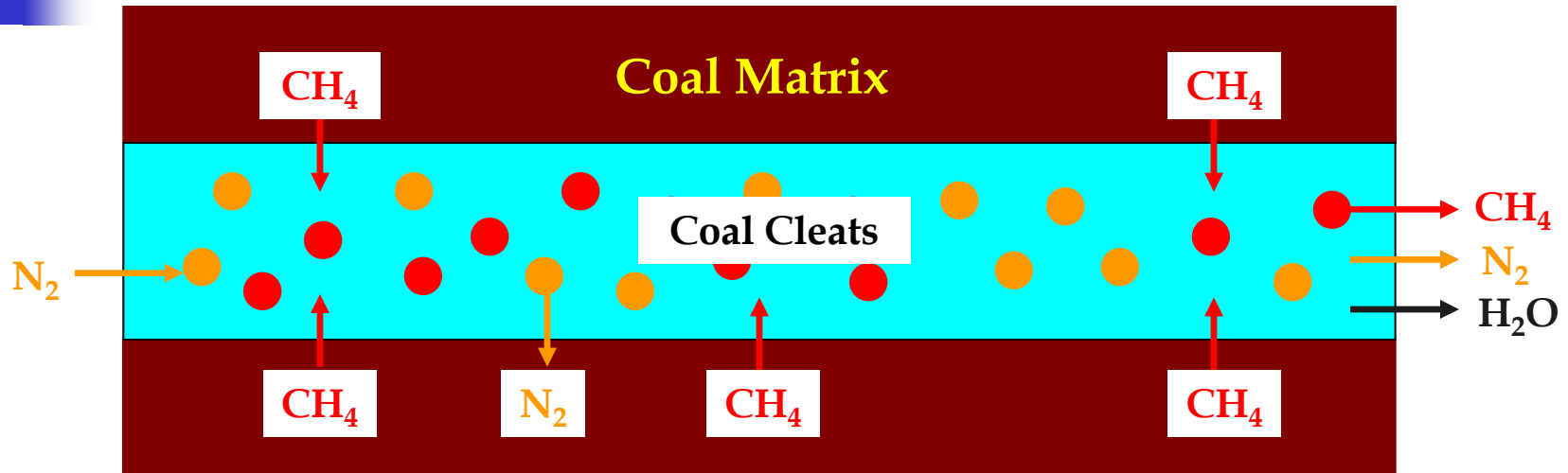


CO₂-ECBM Recovery Mechanisms



- Injected carbon dioxide in cleats
- Increases total cleat pressure
- Carbon dioxide diffuses into matrix and strongly adsorbs onto coal
- Reduces partial pressure of methane in cleats
- Methane desorbs from matrix and diffuses to cleats
- Methane and water flow to wellbore

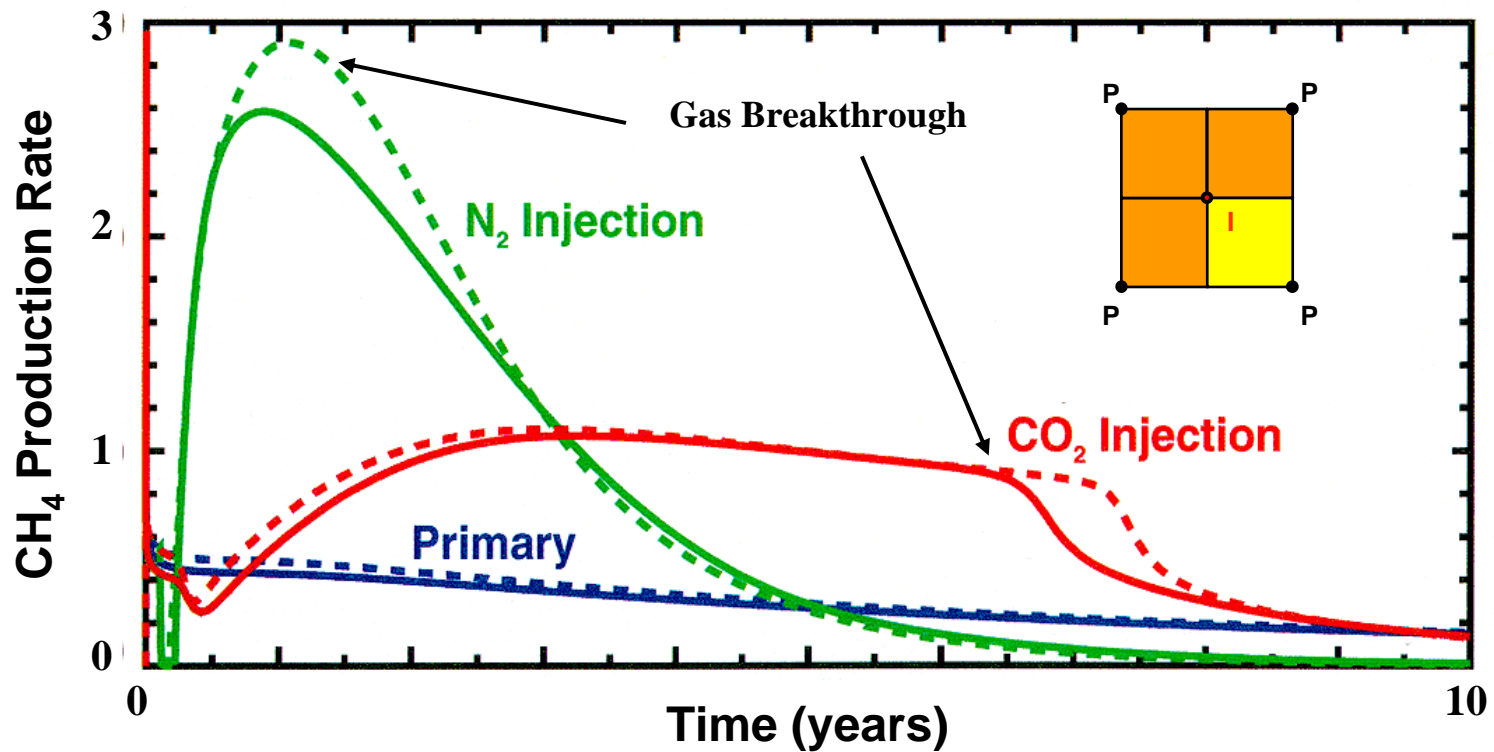
N₂-ECBM Recovery Mechanisms



- Injected nitrogen into cleats
- Increases total cleat pressure
- Nitrogen diffuses into matrix and weakly adsorbs onto coal
- Reduces partial pressure of methane in cleats
- Methane desorbs from matrix and diffuses to cleats
- Methane, nitrogen and water flow to wellbore

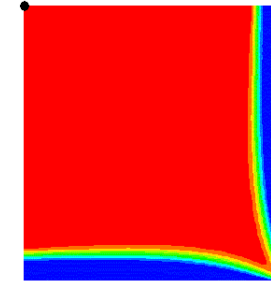
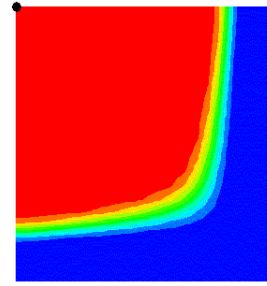
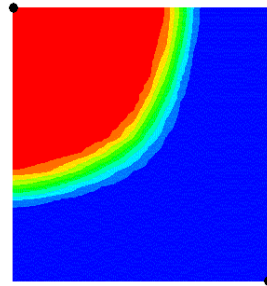
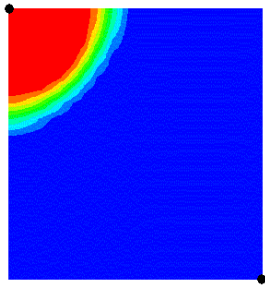
ECBM Production Profile

CH₄ Production Rate

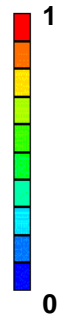


5-Spot Pattern Simulation CO₂ and N₂ Propagation

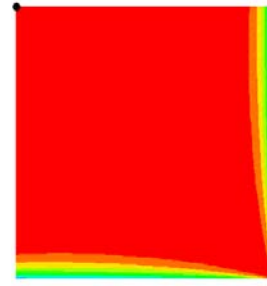
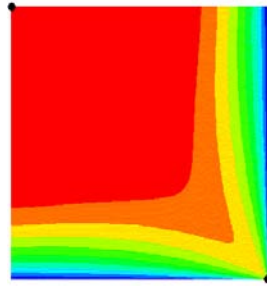
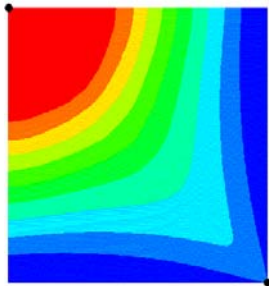
CO₂ Injection



CO₂/N₂ Content



N₂ Injection



After 1 year

After 3 years

After 5 years

After 7 years

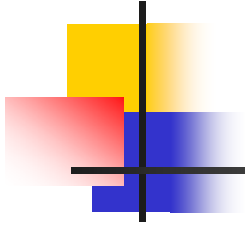
1/4 of 5-Spot Pattern

Constant Injection Rate



ECBM Process

- **CO₂ is stored in the coal and will not breakthrough to the producing wells until most of the coalbed methane is produced**
- **N₂, because it is less adsorbing, will be produced with the coalbed methane and breakthrough to the producing wells quickly**



2 Laboratory Measurements of CO₂ and CH₄ Adsorption

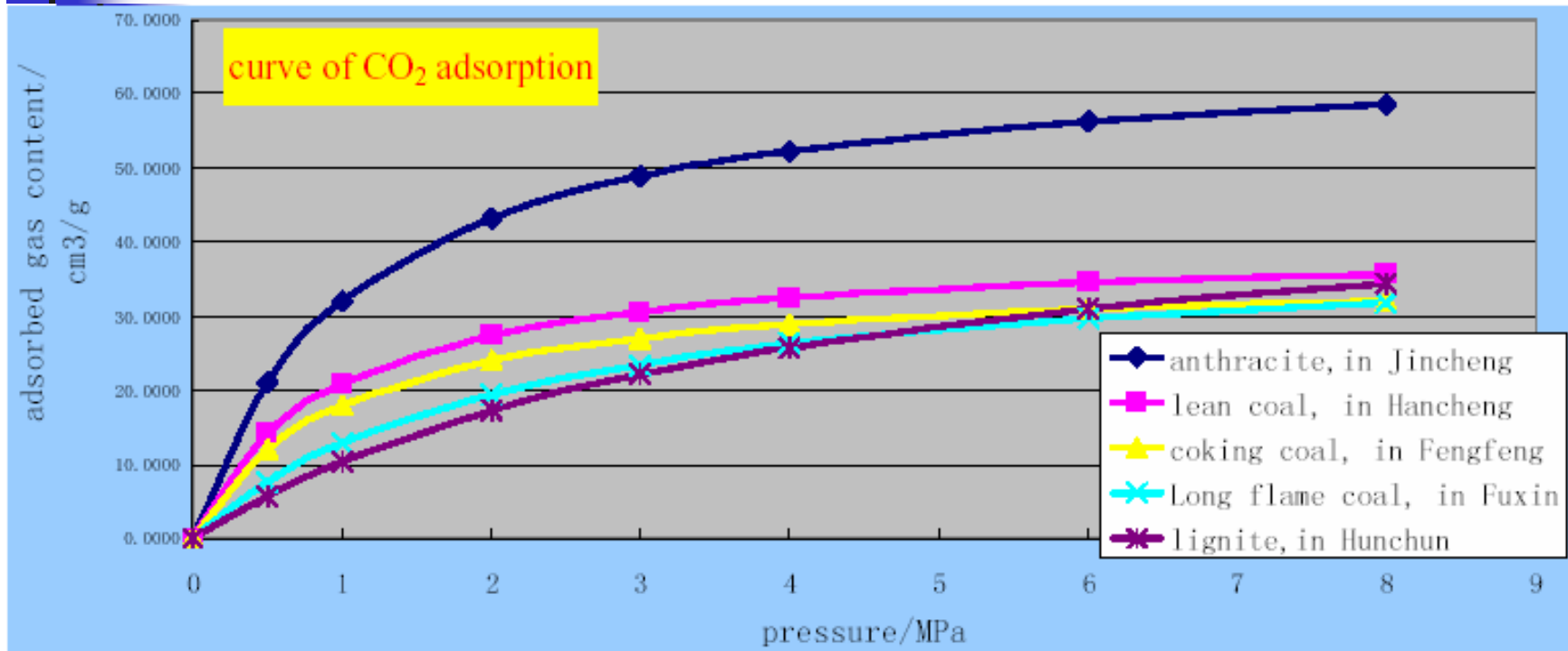


2 Laboratory Measurements of CO₂ and CH₄ Adsorption

Experiment of CH₄ and CO₂ adsorption/desorption in five coal samples with different rank :

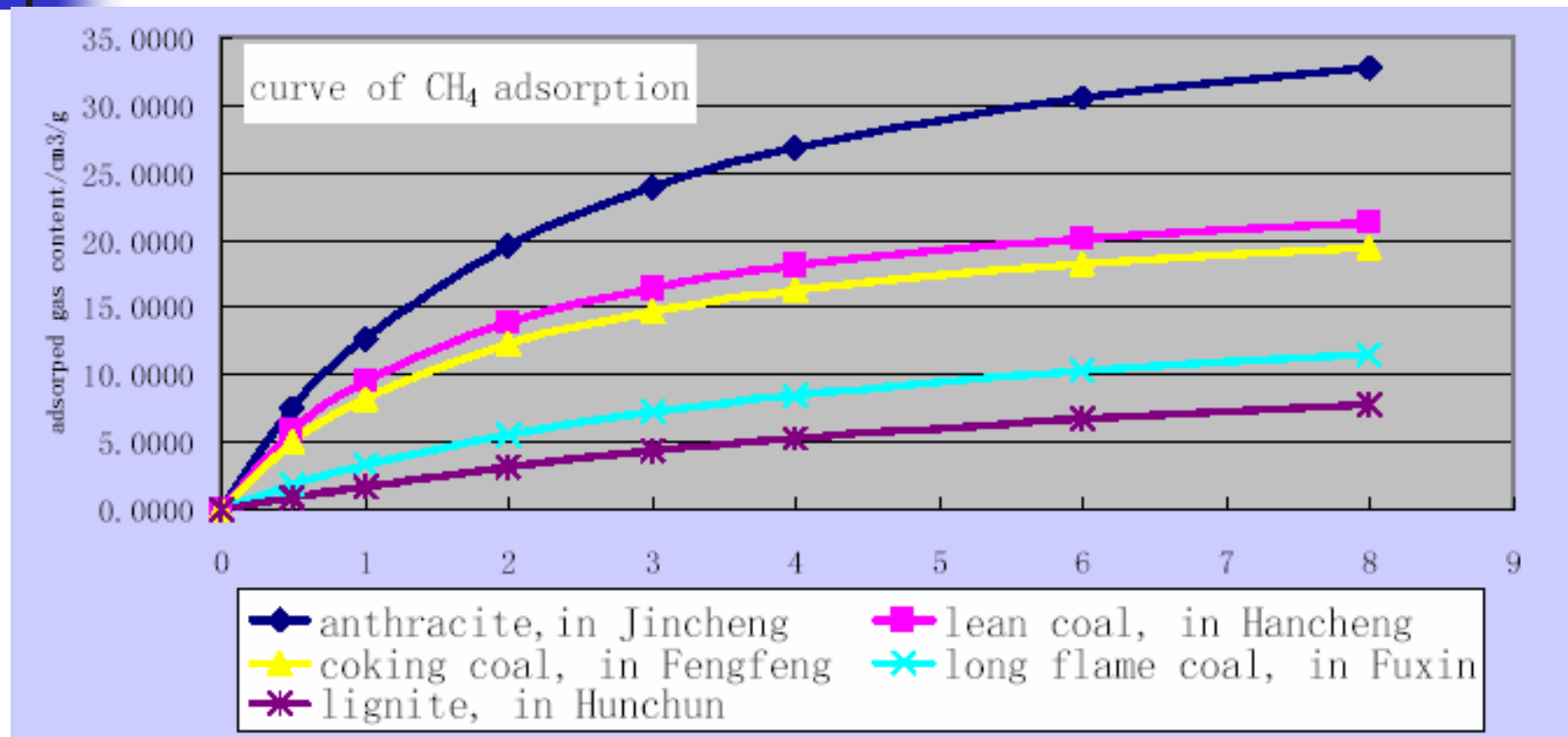
- Anthracite (coal sample Ro 3.62%)
- Lean coal (Ro 1.94%)
- Coking coal (Ro 1.52%)
- Long flame coal (Ro 0.56%)
- lignite (Ro 0.49%)

2 Laboratory Measurements of CO₂ and CH₄ Adsorption



CO₂ adsorption capacity increases when coal rank increases.

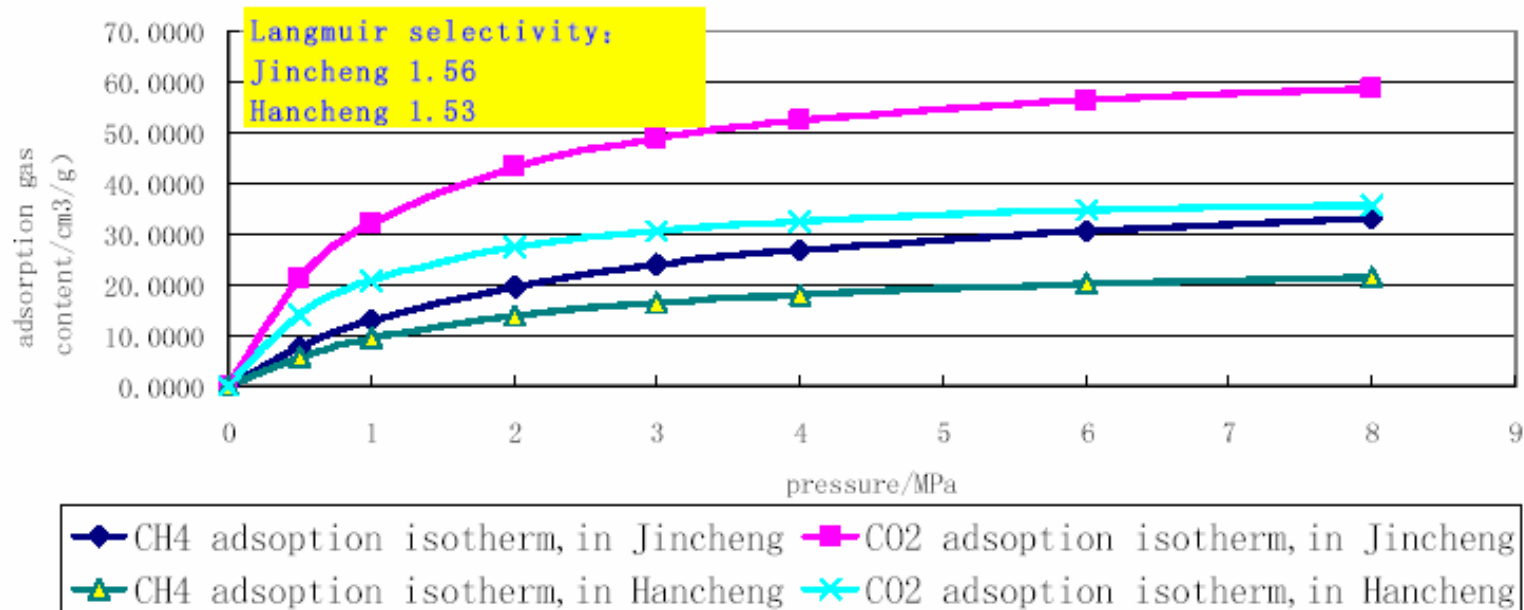
2 Laboratory Measurements of CO₂ and CH₄ Adsorption



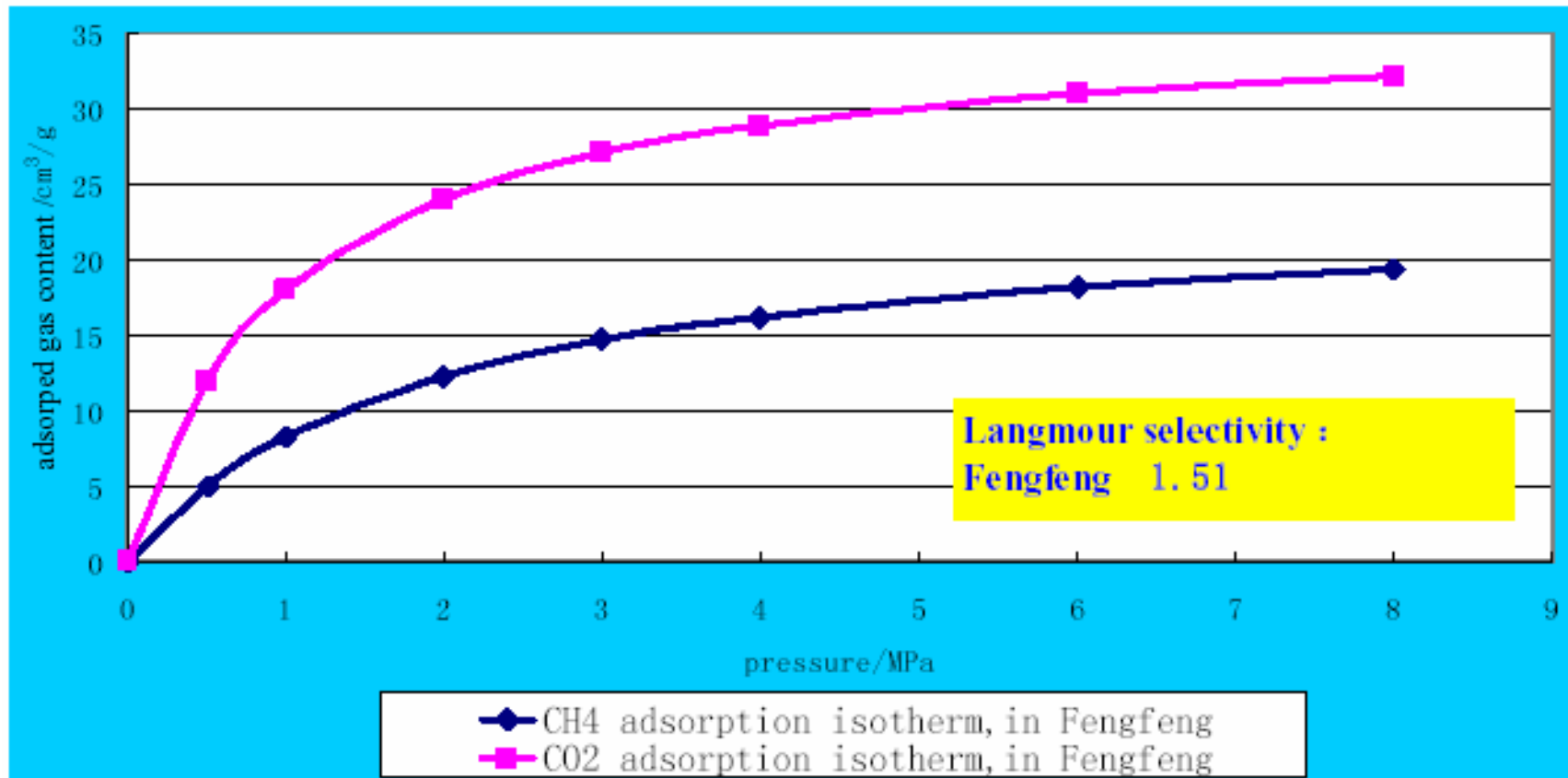
CH₄ adsorption capacity increases when coal rank increases.

2 Laboratory Measurements of CO₂ and CH₄ Adsorption

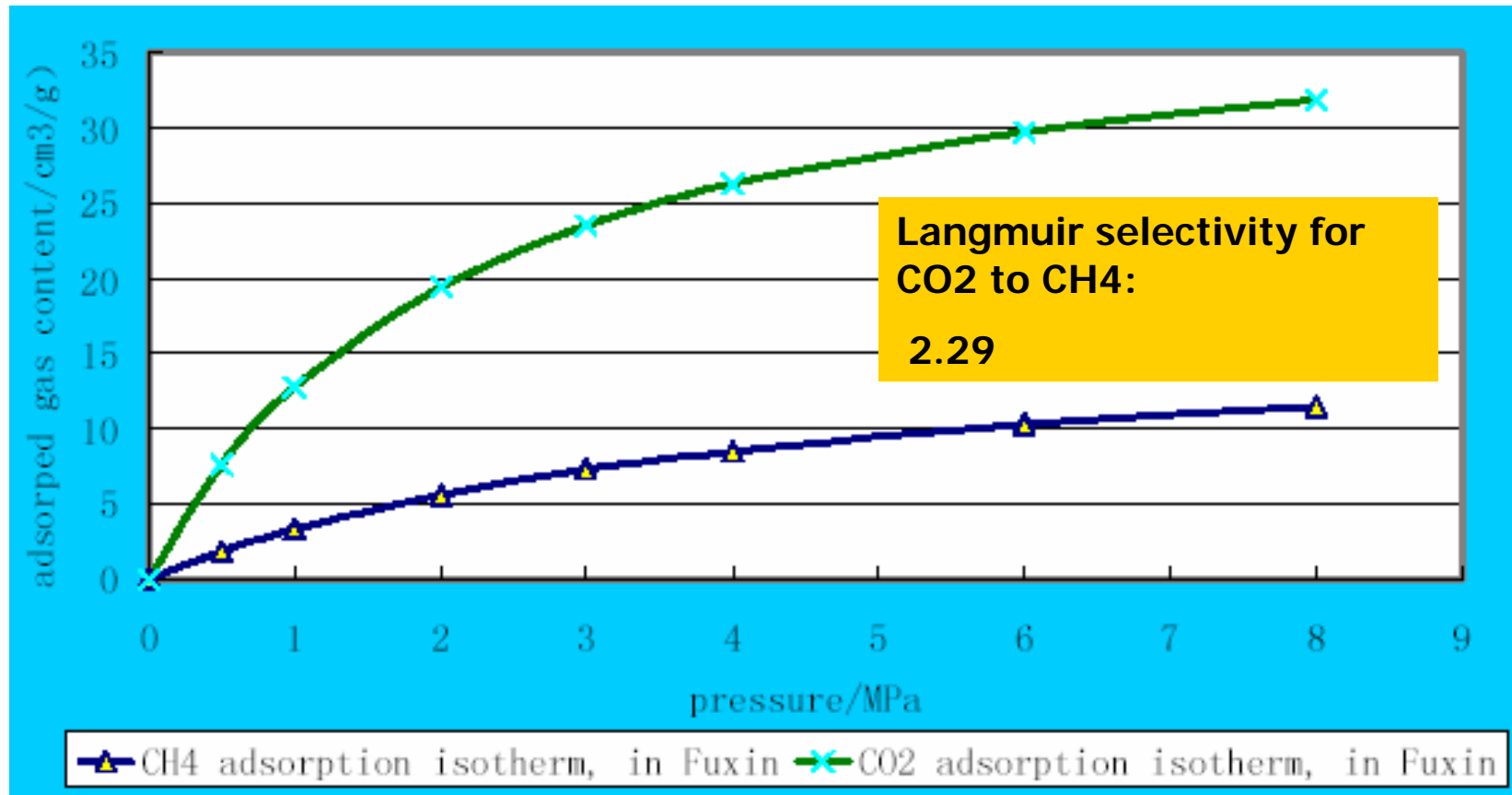
- ❖ CO₂ Adsorption capacity is greater than CH₄.
- ❖ CO₂ Adsorption selectivity decreases relative to methane, when coal rank increases. Langmuir selectivity for CO₂ to CH₄ are from 3.3:1 to 1.5:1 from lignite to anthracite.



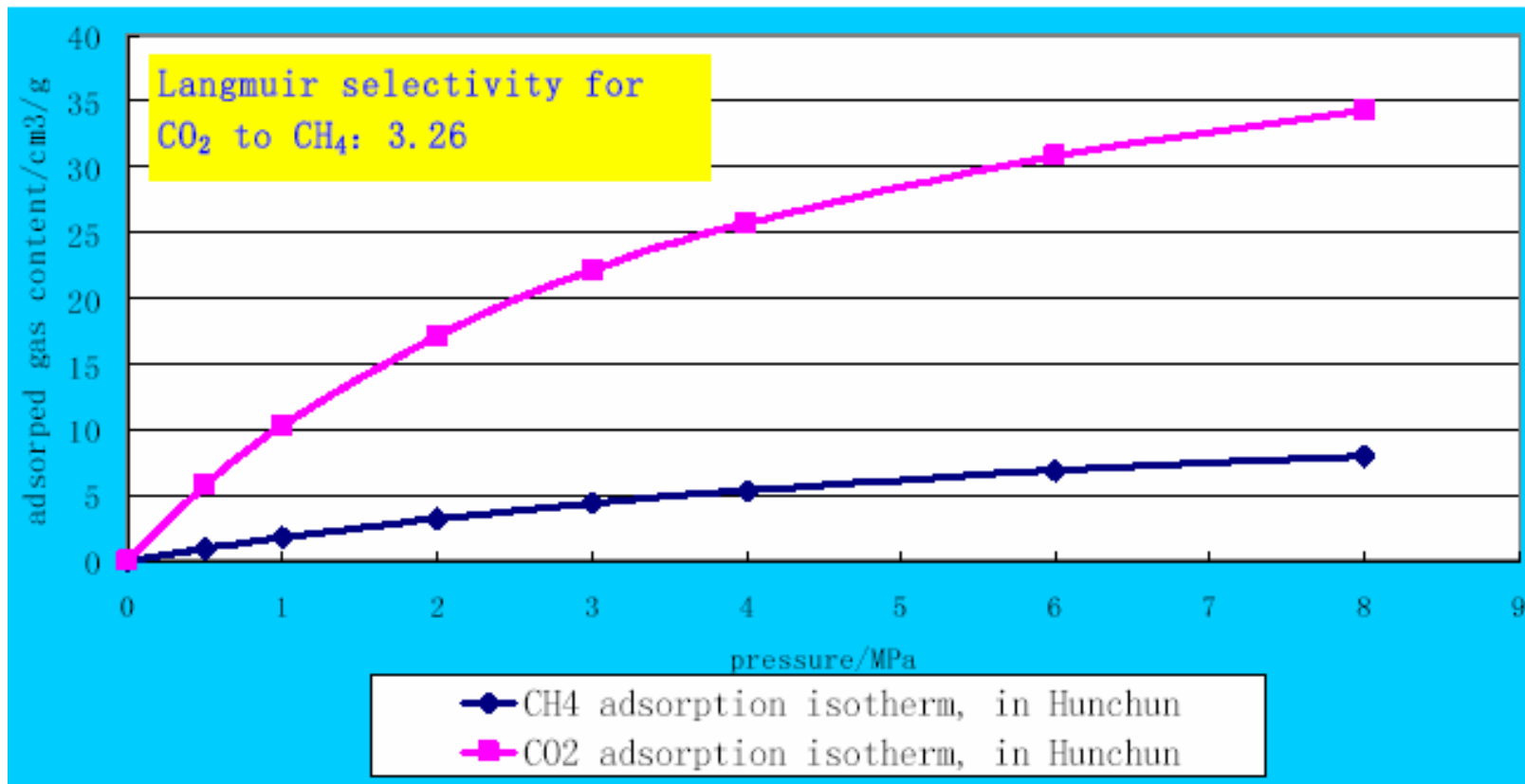
2 Laboratory Measurements of CO₂ and CH₄ Adsorption



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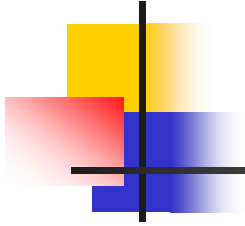




2 Laboratory Measurements of CO₂ and CH₄ Adsorption

Experiment results:

CO₂ and CH₄ adsorption capacity also increases when coal rank increases. But Langmuir selectivity for CO₂ to CH₄ decreases when coal rank increases. Langmuir selectivity for CO₂ and CH₄ is greater in the lignite than in the anthracite.



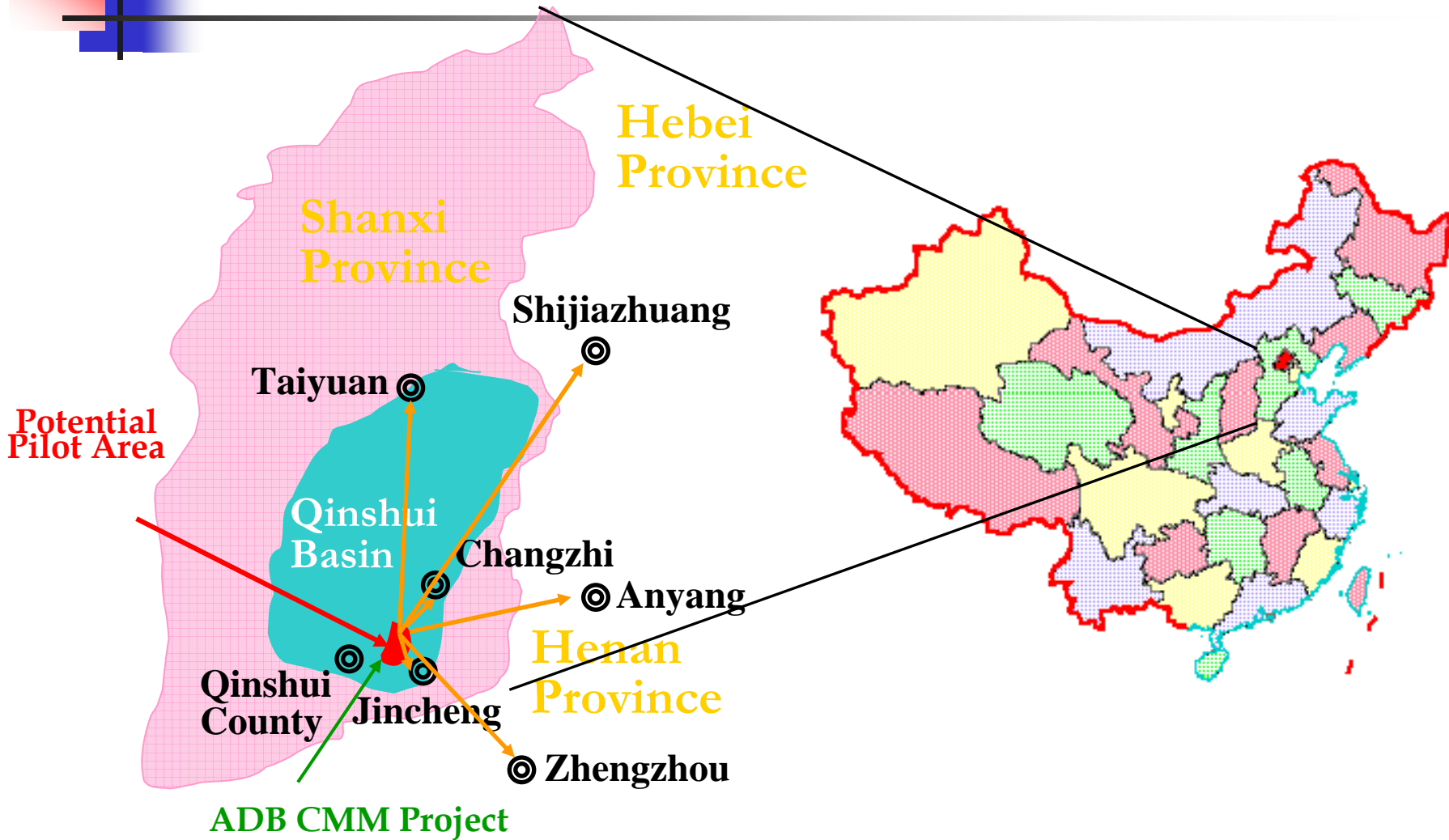
3 Micro-pilot field test in south Qinshui basin



China United Coalbed Methane Co.,Ltd (CUCBM)

- **State-owned company under the direct auspices of the State Council, including the State Plan, Finance, Science and Technology**
- **Exclusive rights for exploration, development and production of CBM in cooperation with foreign companies**
- **Professional company responsible for exploration, development, production and sale of CBM in China**

Demonstration Site Location





Activities in South Qinshui Basin

- 170 wells and more than 660 2-D seismic lines have been completed by CUCBM.
(Up to Aug. 18, 2005)
- 3 CBM pilots have been set up.
- 1 National test field for CBM development has been confirmed.
- 1 Z-pinnate System has been tested.
- 1 CO₂ micro-pilot

China ECBM Project



**Canadian International
Development Agency
(CIDA)**

**Ministry of Commerce
(MOFCOM)**

**Canadian Climate
Change Development
Fund (CCCDF)
(CA \$ 5 million)**

**China United Coalbed
Methane Corporation
Ltd. (CUCBM)
(CA \$ 5 million)**

**3.5 - year CA \$ 10 million Project
(Started March 2002)**

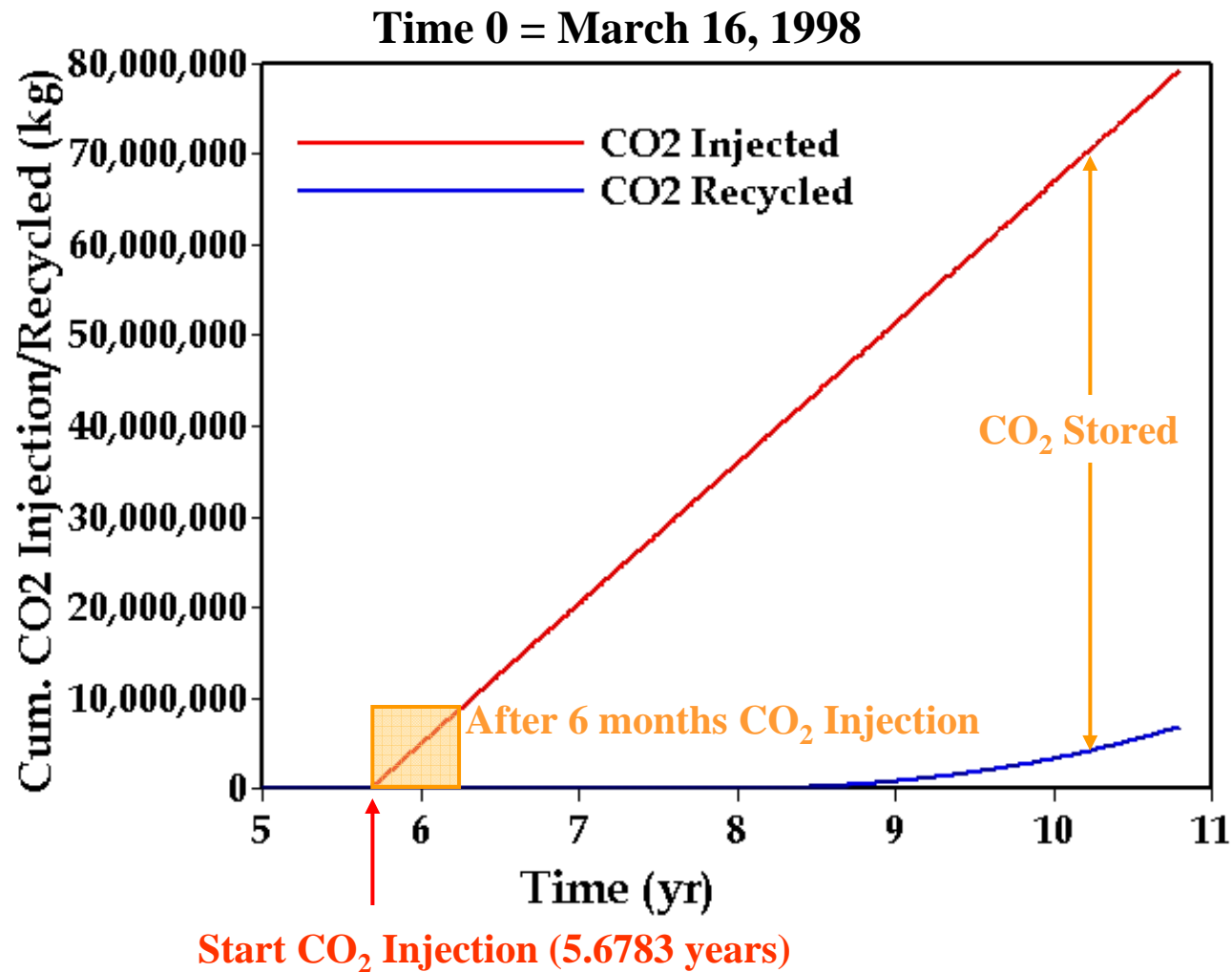


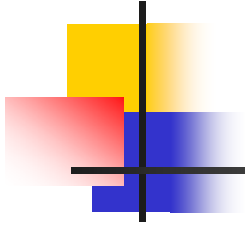
First Micro-Pilot Test

Qinshui Basin

- The first micro-pilot test was successful
- CMG's GEM CBM Model has been validated based on successful history match of the micro-pilot field data
- Prediction of the performance of CO₂-ECBM recovery process indicated that more than 4 times the average CH₄ production rate compared to primary recovery can be achieved
- CO₂ storage into high-rank anthracite coal seam in Qinshui Basin is feasible
- Start design of multi-well pilot on site

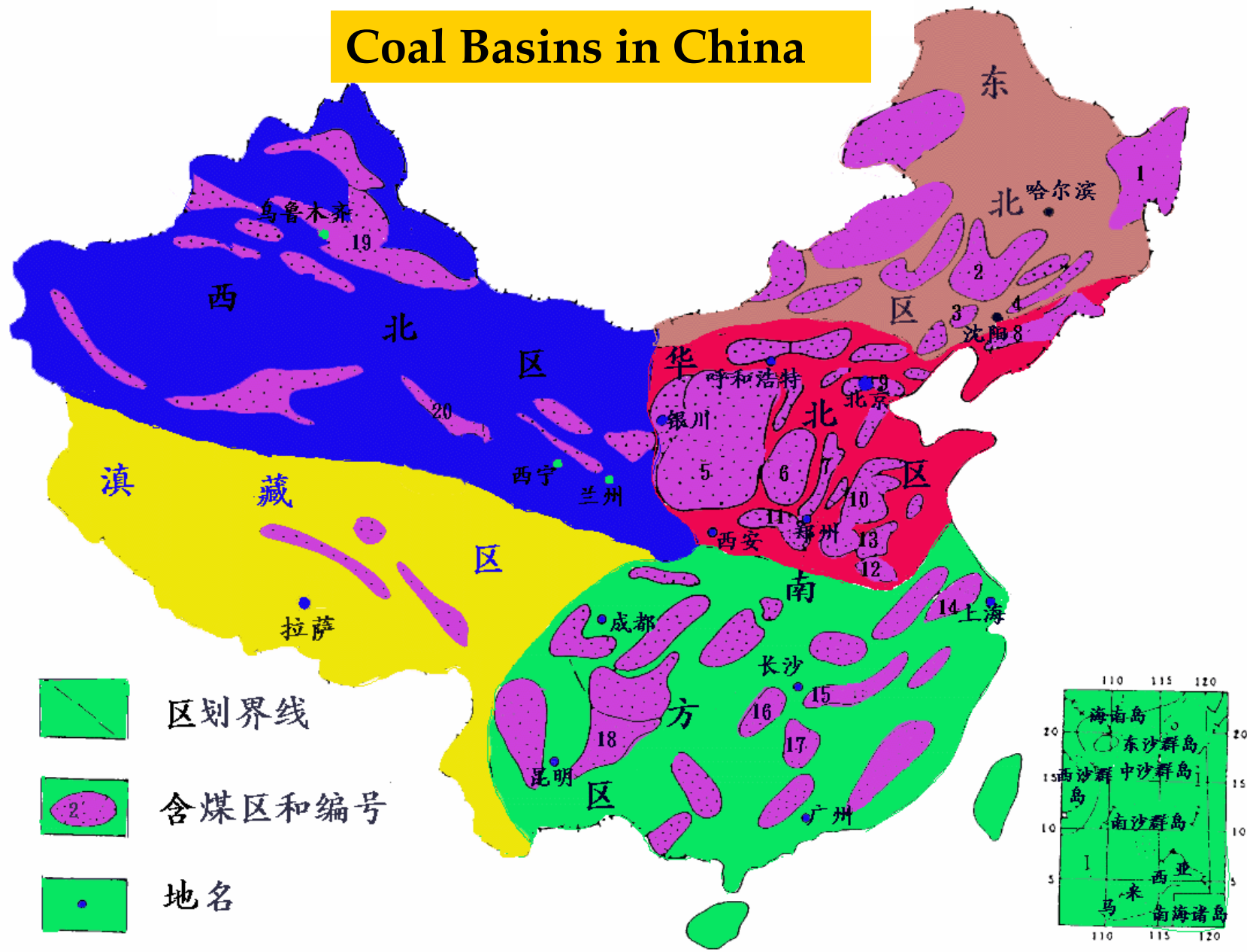
5-Spot Field Pilot Test Prediction CO₂ Inventory





4. CO₂ storage potential in coal seams in China

Coal Basins in China



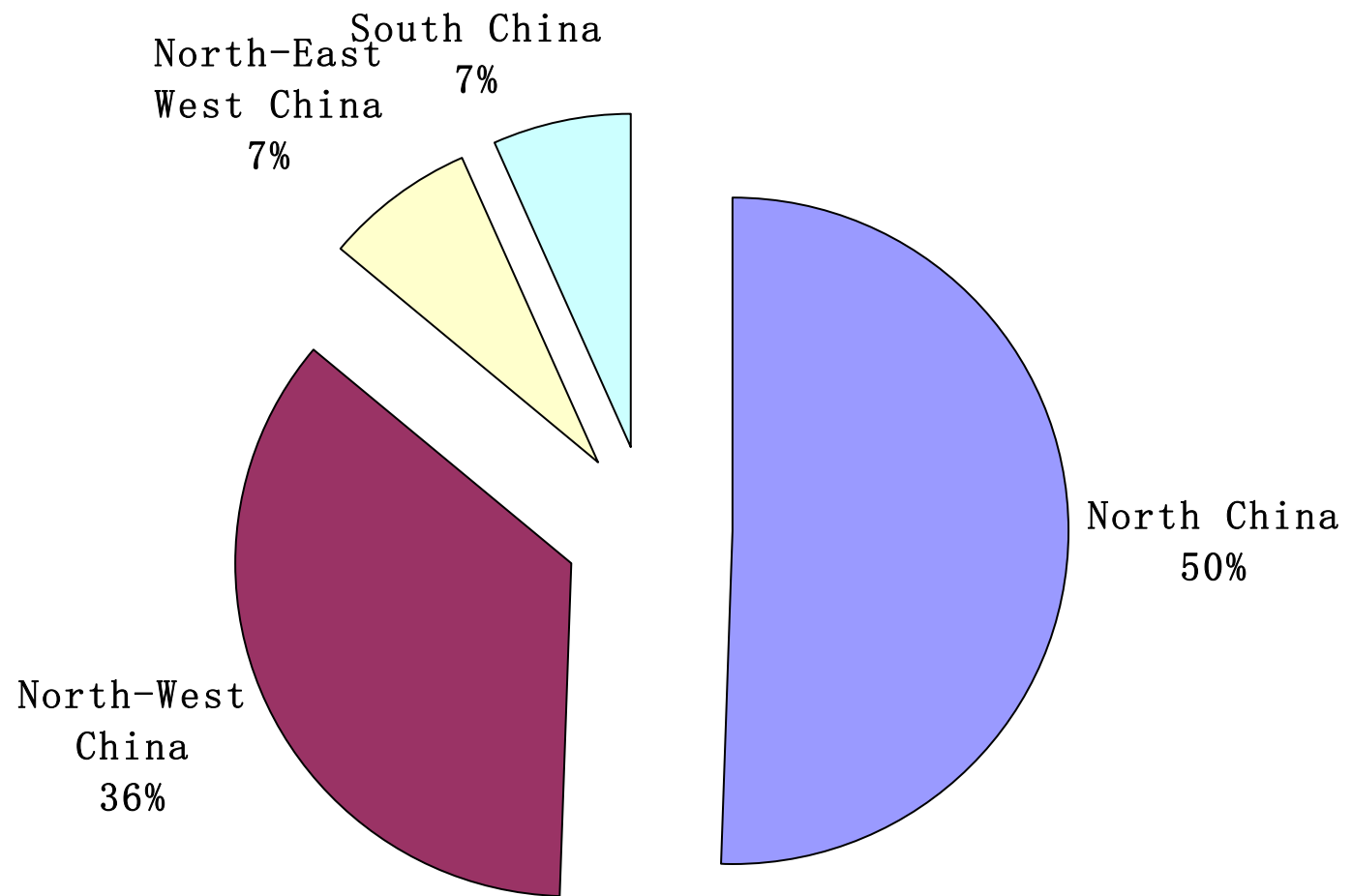


4. CO₂ storage potential in coal seams in China

- coal resource is 5.57×10^{12} t over 2000m depth in China
- coal resource is 2.71×10^{12} t between 1000-2000m depth in China

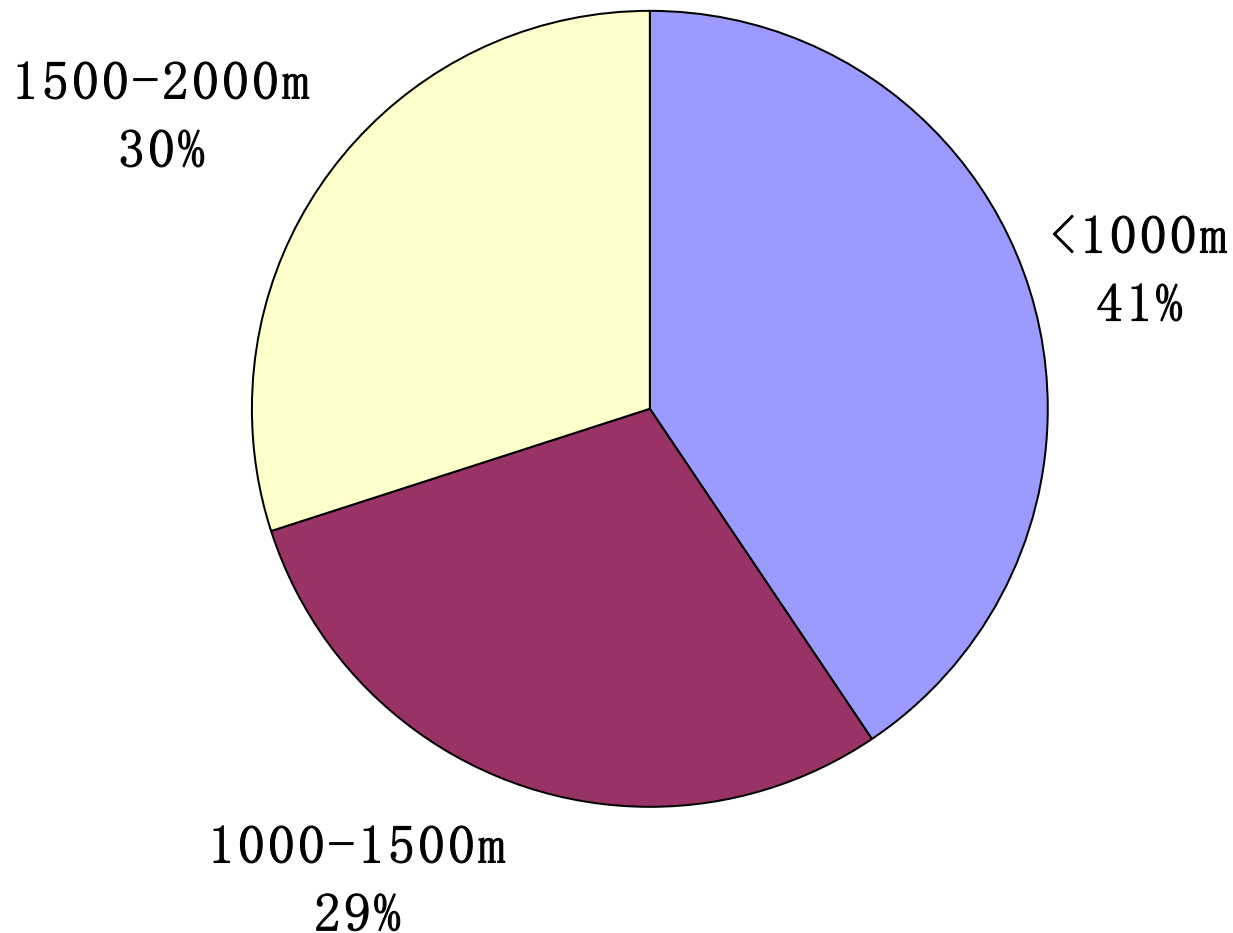
Data from China administration of coal geology, 2000

4. CO₂ storage potential in coal seams in China

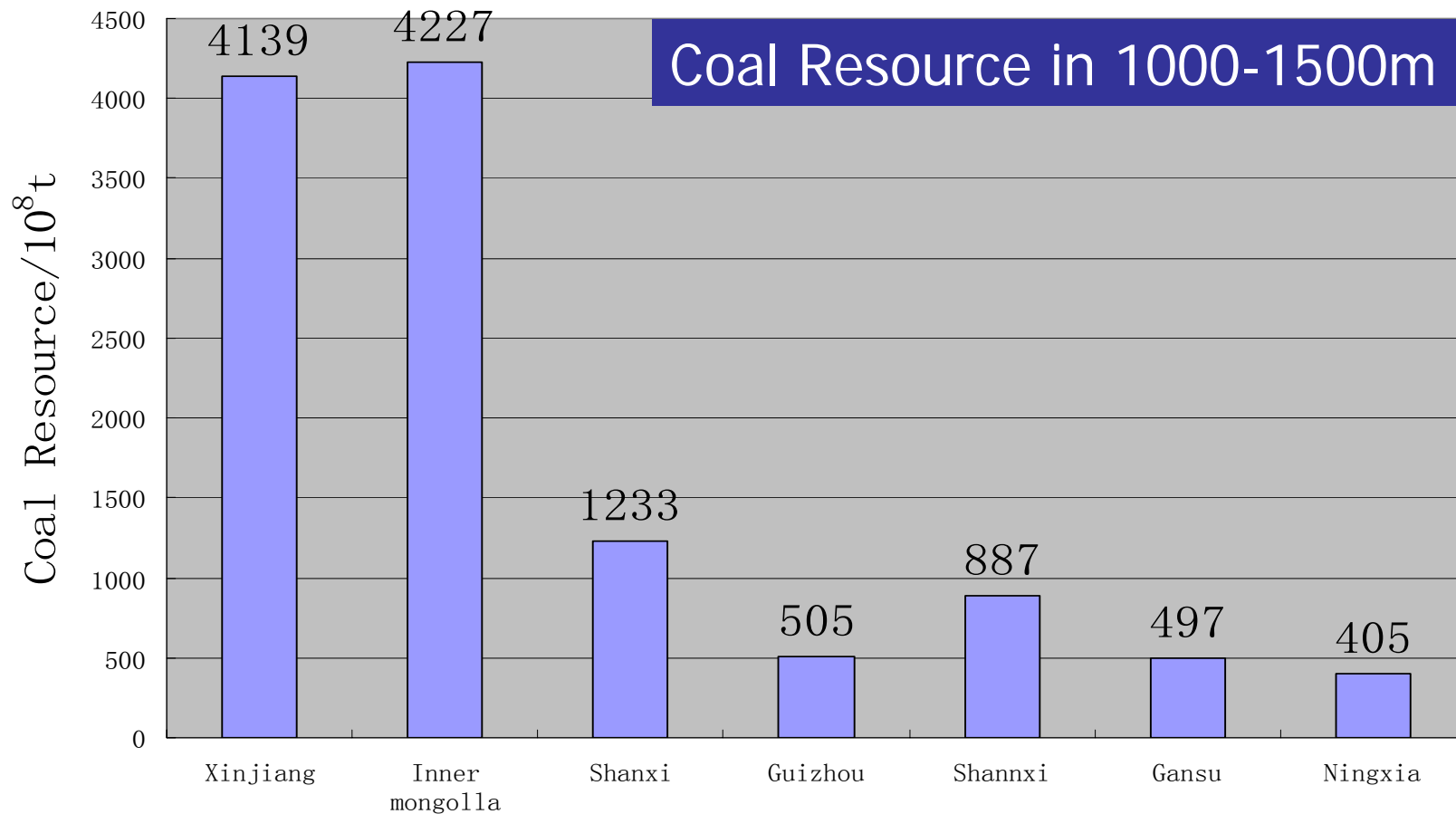


4. CO₂ storage potential in coal seams in China

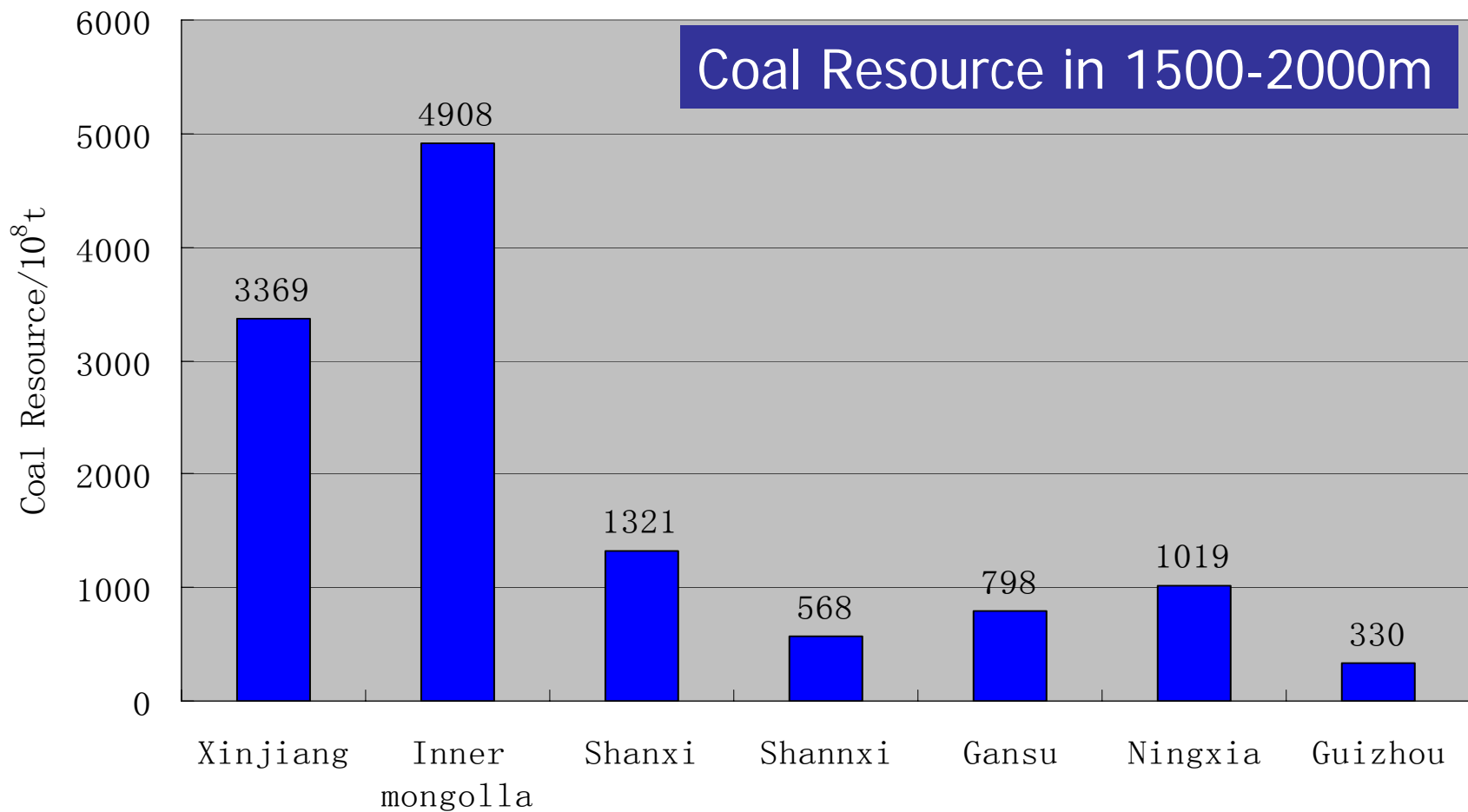
Coal resource for difference depth



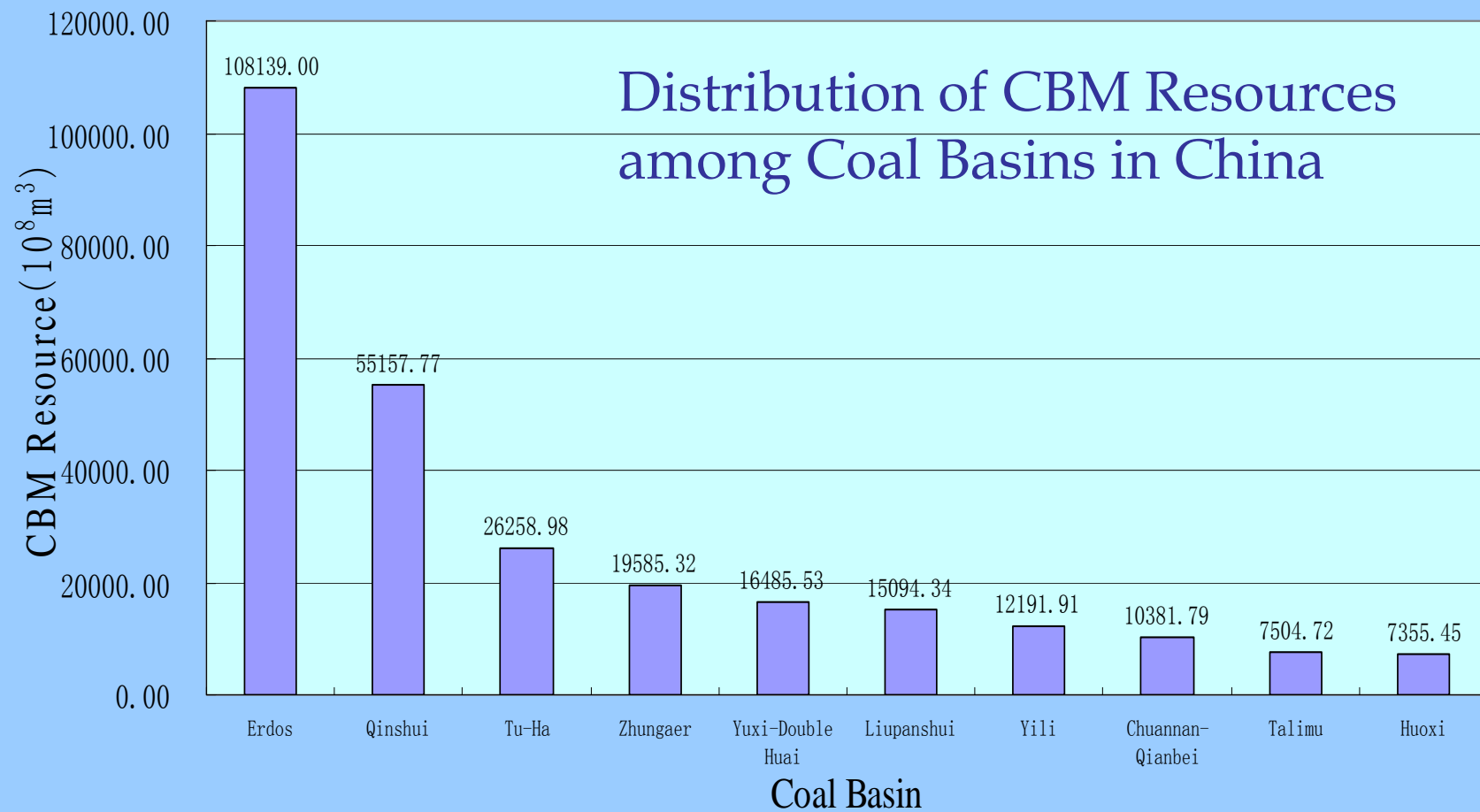
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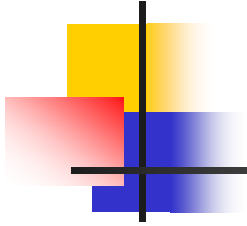
4. CO₂ storage potential in coal seams in China





Summary

- ❑ Coal resource is rich in China, Total Coal resource is 5.57×10^{12} t. coal resource is 2.71×10^{12} t between 1000-2000m depth. Coal mainly distributes in North China and North-west China.
- ❑ That injecting CO_2 to coal seams not only enhance coalbed methane recovery, but also storage CO_2 .
- ❑ CO_2 storage potential on coal is great in China.



THANK YOU