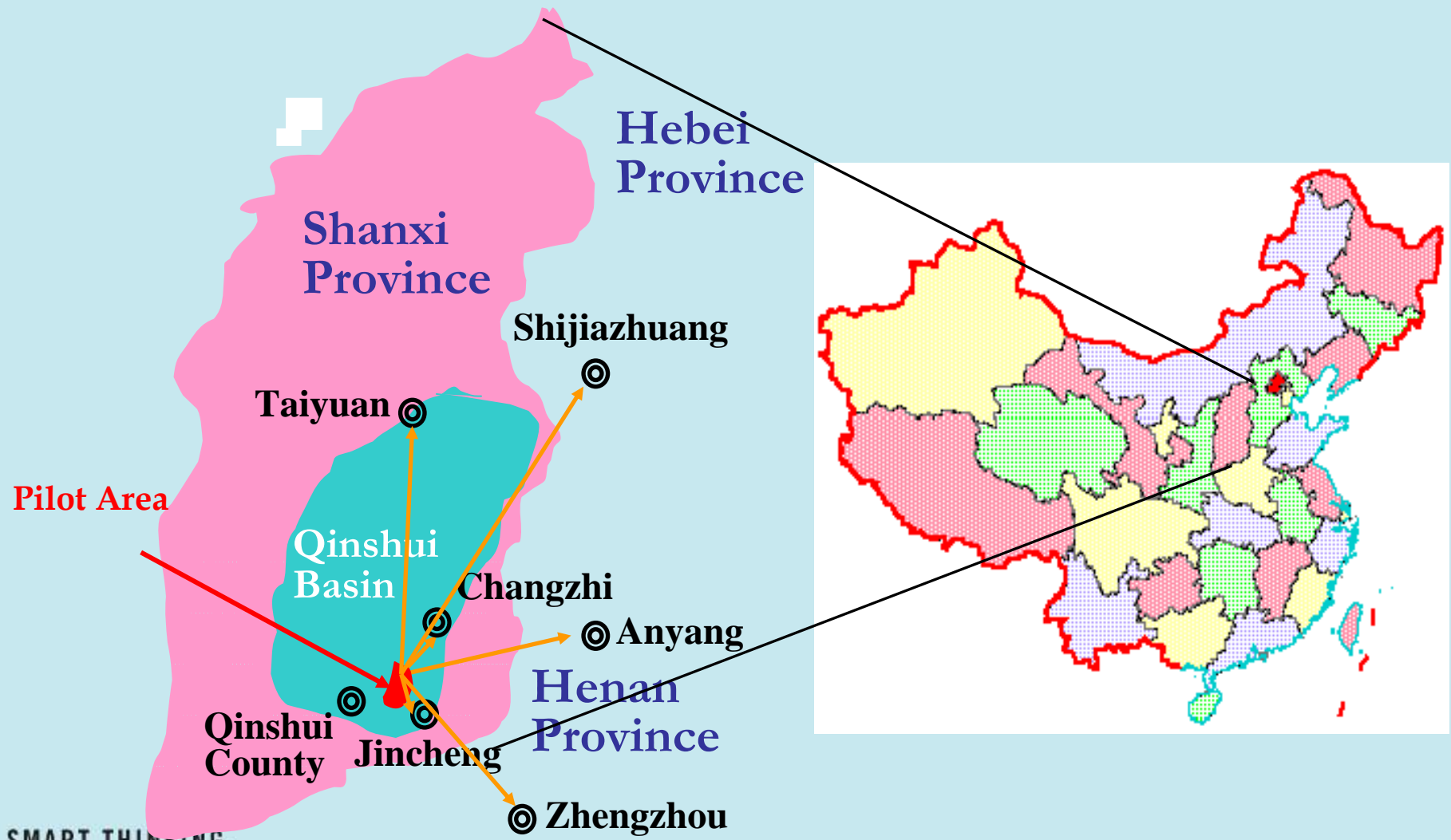


Enhanced CBM Micro-pilot Test at South Quinshu Basin, China

Brent Lakeman
Program Leader, Carbon Management
Alberta Research Council Inc.

Demonstration Site Location



SMART THINKING.
POWERFUL SOLUTIONS.

Objective

- Demonstrate that coal seams in this area are permeable and stable enough to absorb CO₂ and enhance methane production, leading to a clean energy source for China

Project Sponsors



**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)**

Project Participants



CIDA

Canadian Consortium:

- Alberta Research Council (ARC)
- Sproule International Ltd.
- Computer Modelling Group (CMG)
- SNC-Lavalin Inc.
- Computalog
- CalFrac Well Services
- Porteous Engineering

- China United Coalbed Methane Corporation Ltd. (CUCBM)

Micro-Pilot Test Goals

**Enhancement of
CBM recovery
can not be
estimated
directly from
micro-pilot test
data**

- To measure and evaluate data to obtain estimates of reservoir properties and sorption behavior
- To calibrate a simulation model for estimation of the enhancement of CBM recovery in a larger-scale pilot or full field development

Major Tasks



- ✓ Selection, characterization and ranking of 3 pilot sites
- ✓ Design of micro-pilot field test procedures
- ✓ Single well micro-pilot field test at the most suitable site
 - Perform up to three micro-pilot tests to show commercial potential

Major Tasks (Continued)



- ✓ Micro-pilot test evaluation and numerical model calibration and fine tuning
- Large-scale pilot design leading to commercial production
(pending)
- Training and technology transfer between Canada and China
(pending)

Attractiveness of Qinshui Basin

**No. 3 Seam – Shanxi
Formation**

Age: Carboniferous
Permian coal

Depth: 478 meters

Average thickness: 6
meters

**Reservoir temperature
& pressure:** 25C & 500
psi

- Large areal extent
- Thick, laterally continuous coal seams
- Relatively shallow depths of coal seams
- Highest gas contents measured in China
- Reasonable access to local markets and pipelines
- Relatively more explored than other basins

Cooling Down the System



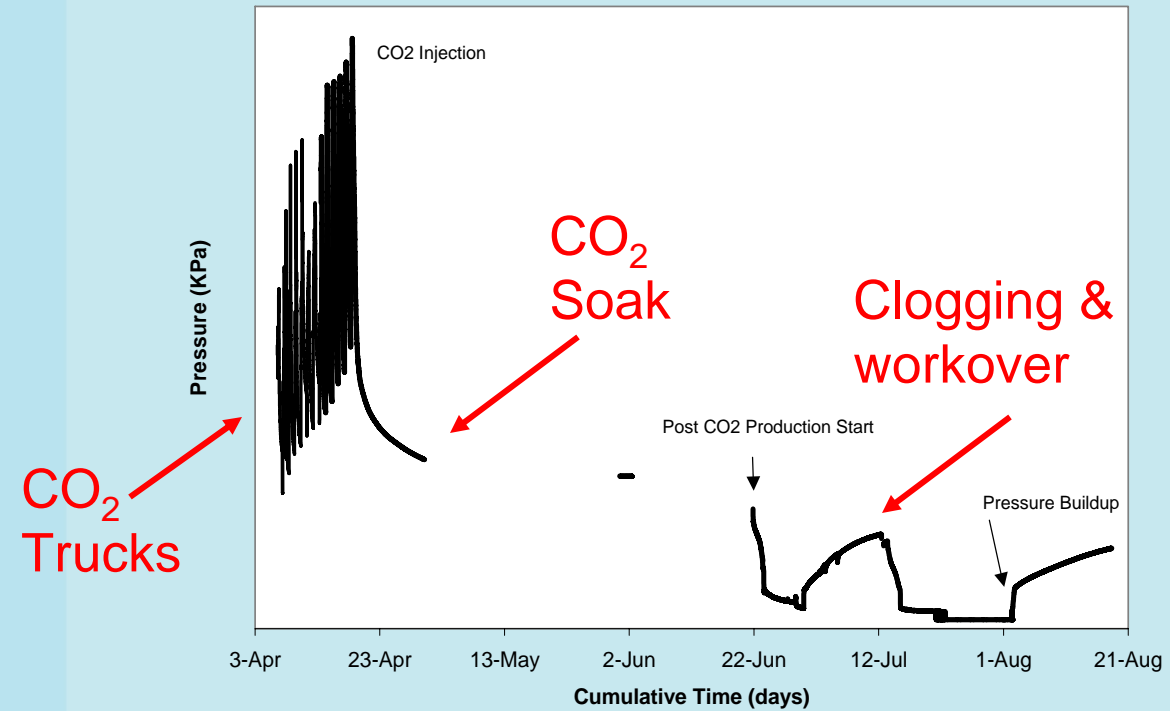
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Injecting Liquid CO₂



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Micro Pilot Results



Design of 5-Spot Field Pilot Test

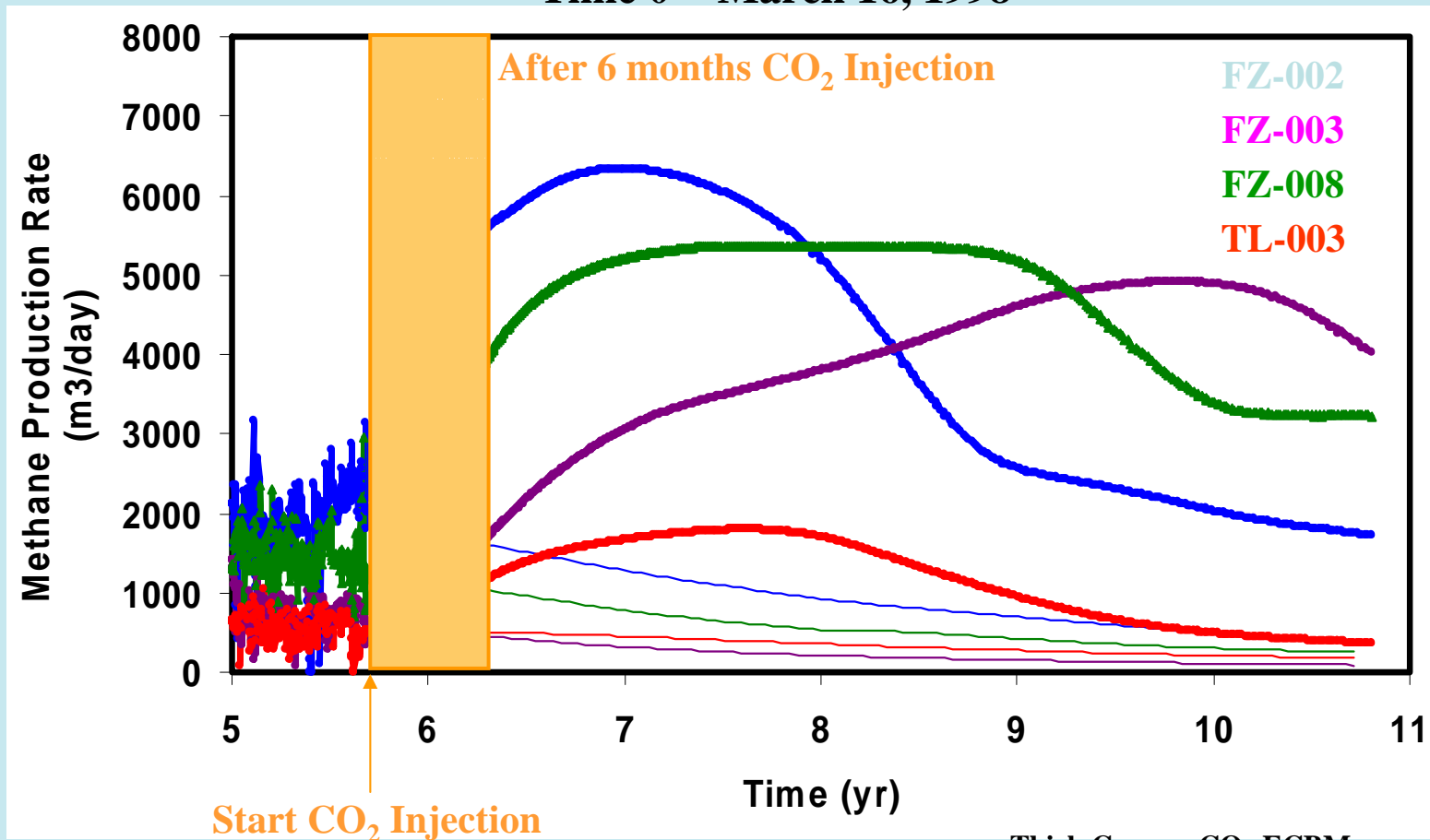
Numerical Simulation Scenario

- Continue after history matching run (November 19, 2003)
- Start CO₂ injection at new injector at a constant rate of 22,653 m³/d (0.8 MMscf/d)
- Continuous production at all four wells

5-Spot Field Pilot Test

Methane Production Rate

Time 0 = March 16, 1998

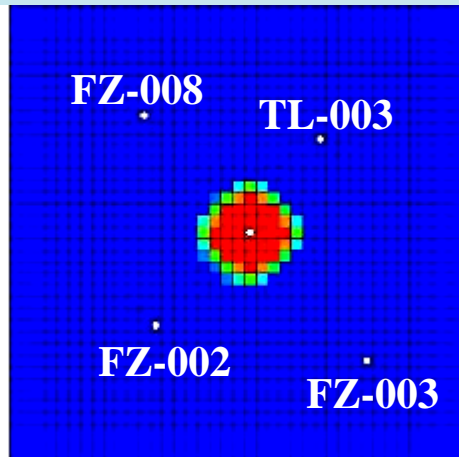


Thick Curves: CO₂-ECBM

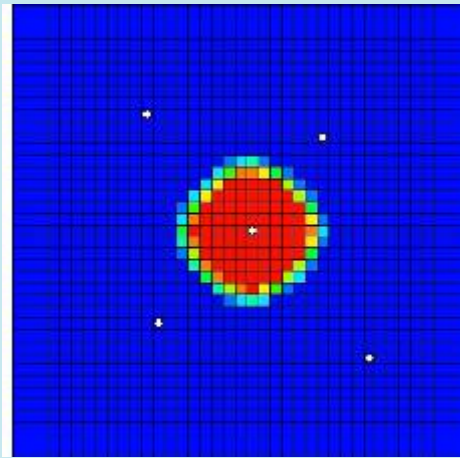
Thin Curves: Primary CBM

5-Spot Field Pilot Test

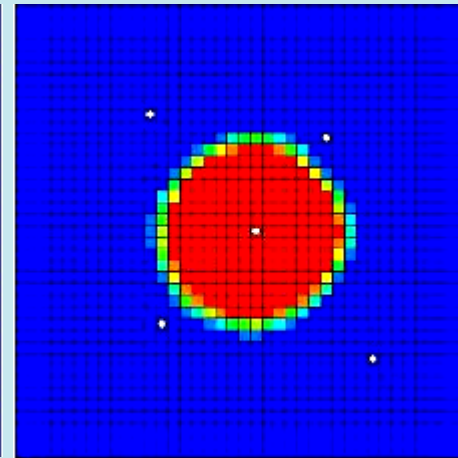
CO₂ Distribution in Coal Seam #3



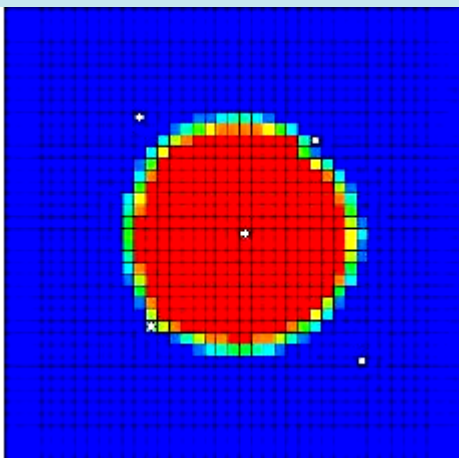
6 months



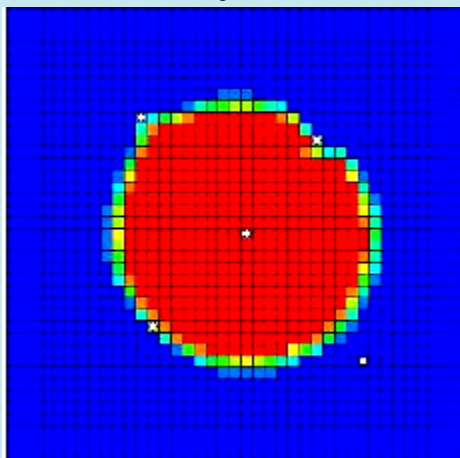
1 year



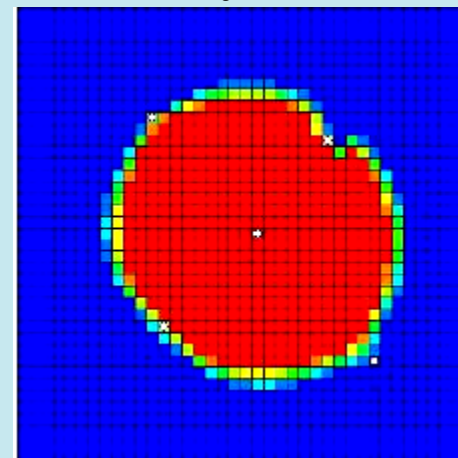
2 years



3 years

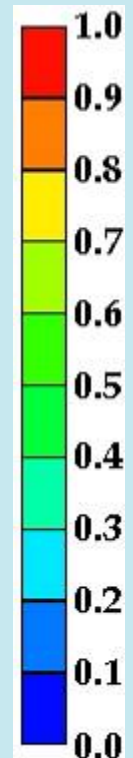


4 years



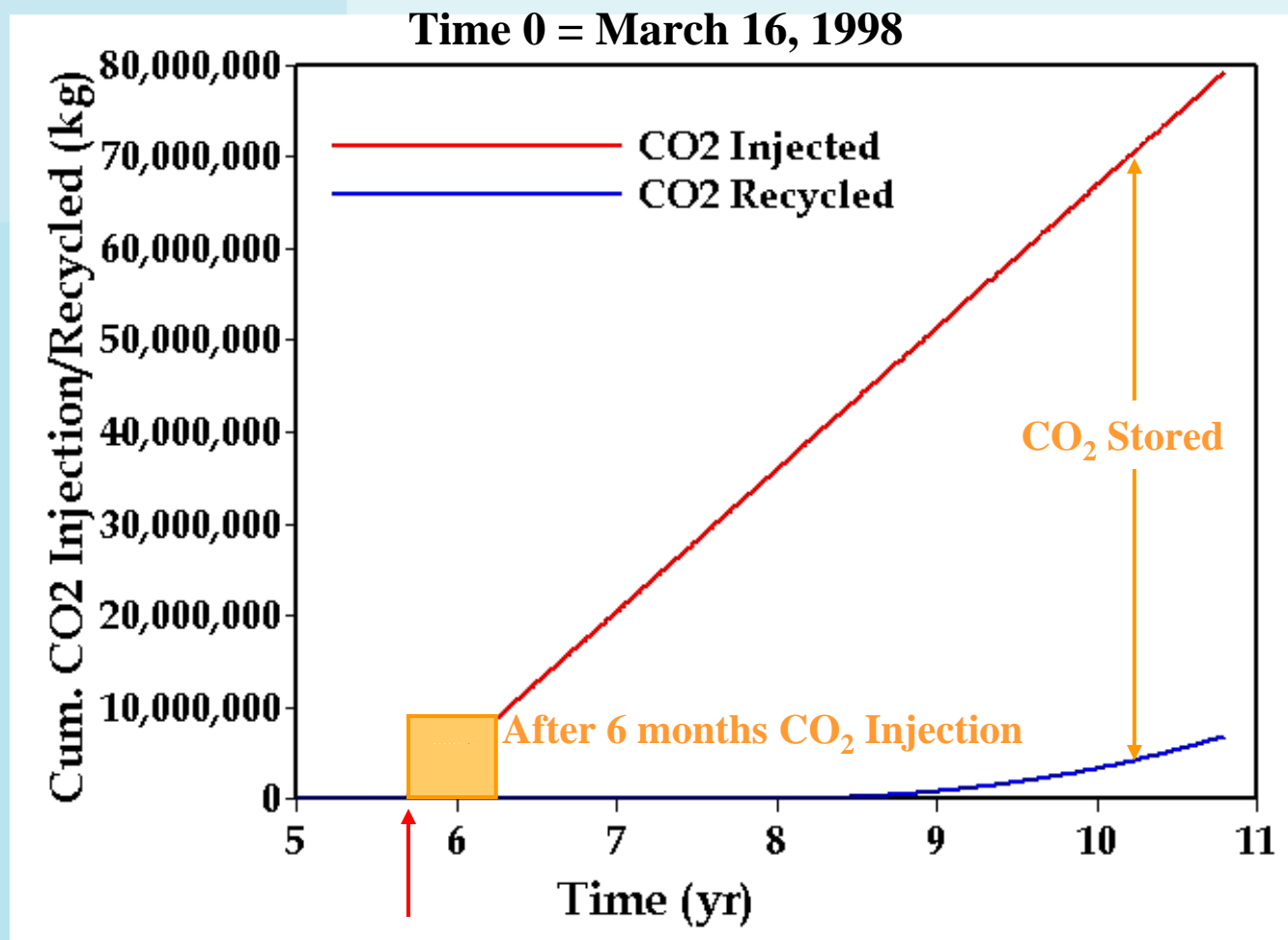
5 years

CO₂ Mol Fr.
in Fracture



5-Spot Field Pilot Test

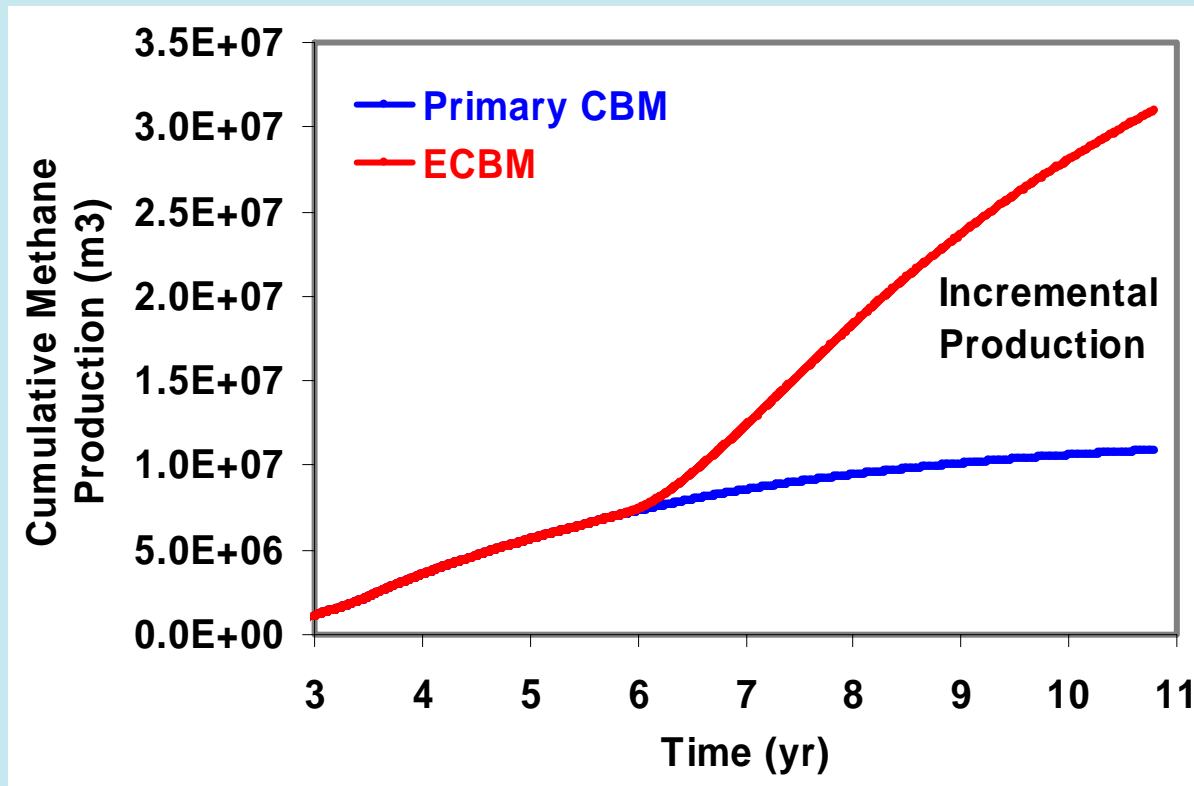
CO₂ Inventory



Start CO₂ Injection (5.6783 years)

5-Spot Field Pilot Test

Cumulative CBM Production



Next Steps

- Initial commercial economic evaluation
- Training and technology transfer in Canada and China continues

Conclusions

- Successful completion of micro-pilot test that met all technical objectives
 - 192 metric tonnes of CO₂ was injected
 - CO₂ soak for 30 days
 - Injectivity decreased during injection but permeability rebounded after an extended production period of 1 month
 - Production for 60 days measuring gas composition, pressures and flow rates
- History matching indicates a significant production enhancement compared to primary production
- Substantial CO₂ storage in the coal seam is feasible in a multi-well project

For More Information

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