

CO₂ Storage in Depleted Gas Pools

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Talking in Calgary about Global Warming!

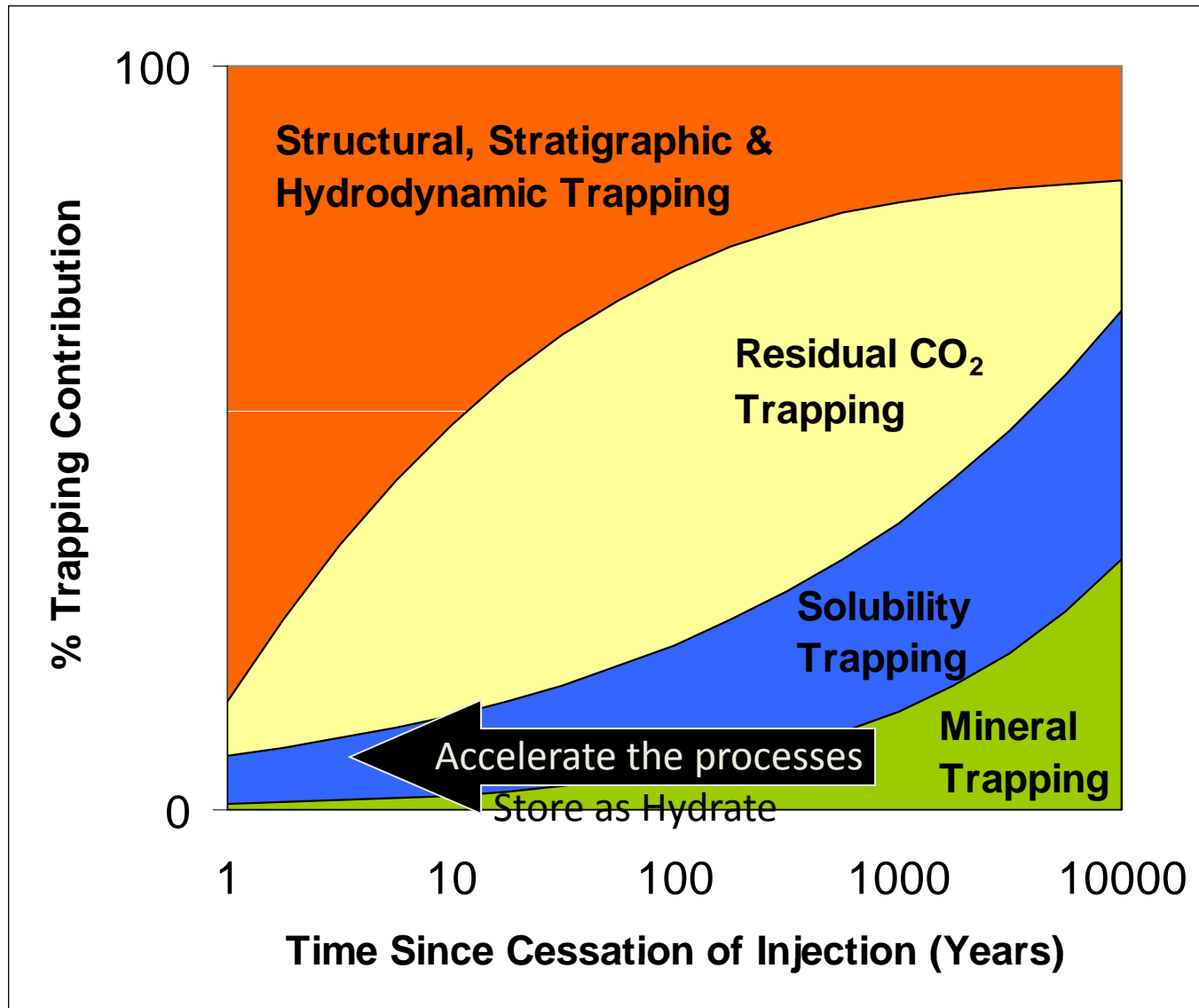
Storing at shallow depths!

A few assumptions ...

The premise

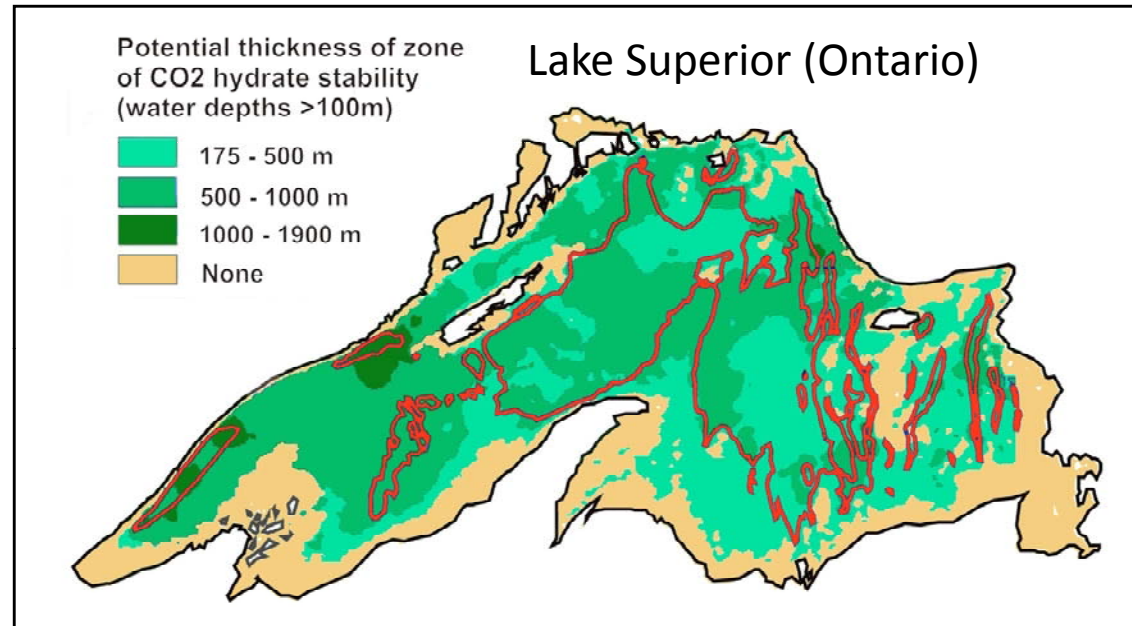
- We want to reduce our CO₂ emissions
- The volumes are large – 10 to 15 Bcf/day in Alberta
- Many mitigation pathways are being considered
- Geological storage of CO₂
 - EOR
 - Large scale storage in aquifer

Motivation



Possibilities in Canada

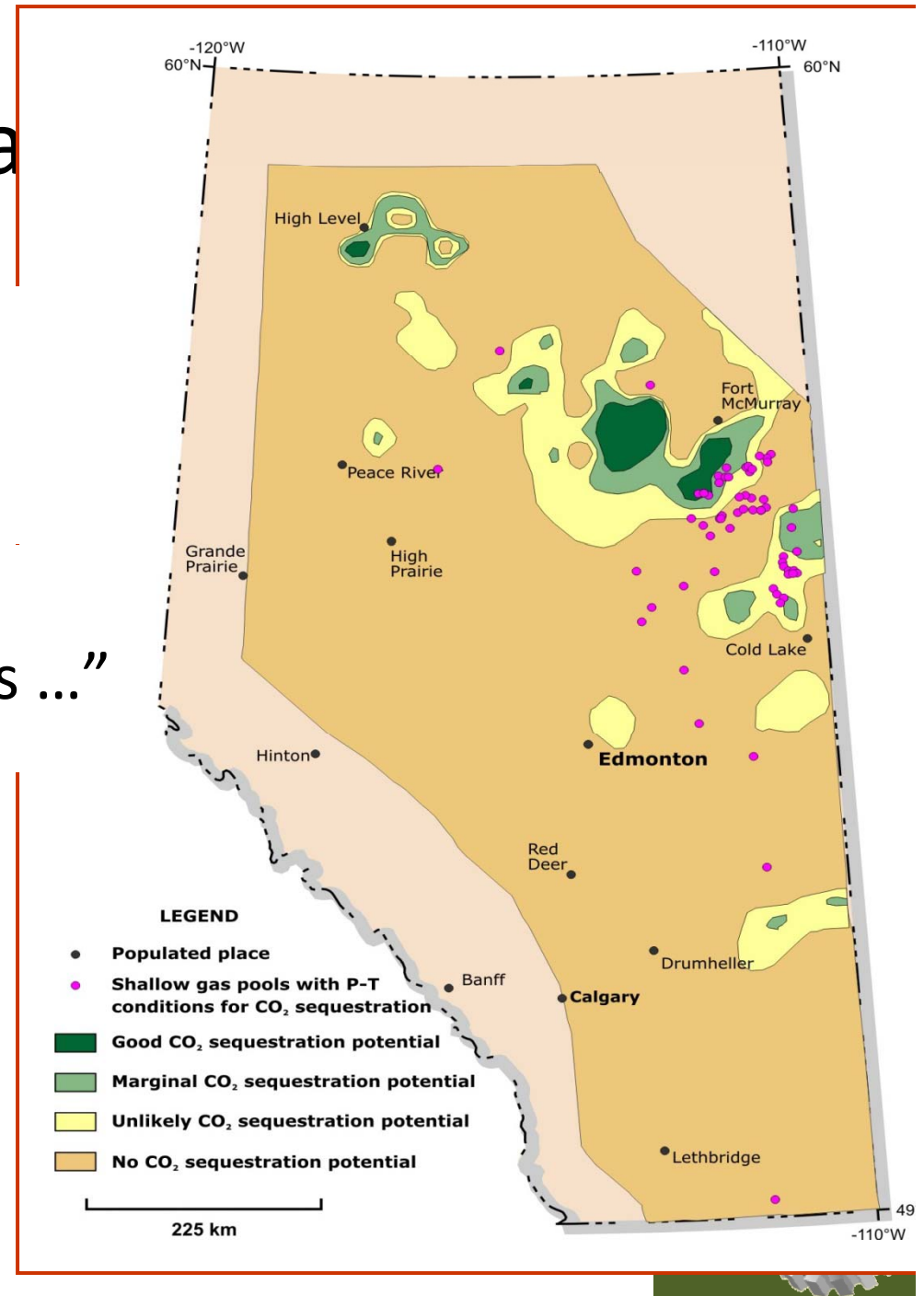
- Geological Survey of Canada (Wright et al. 2006)
 - Pressure regime
 - Geothermal gradients
 - Water chemistry
 - Volume of reservoir rock
 - Location of emitters
 - Effect of global warming
- “Preliminary evaluation”



Wright et al. 2008 (Courtesy Fred Wright)

Possibilities in Alberta

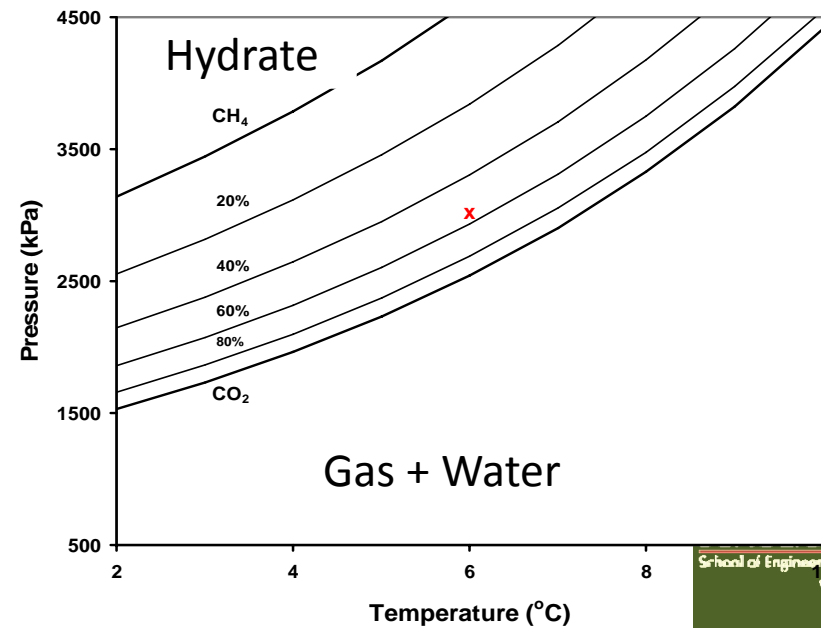
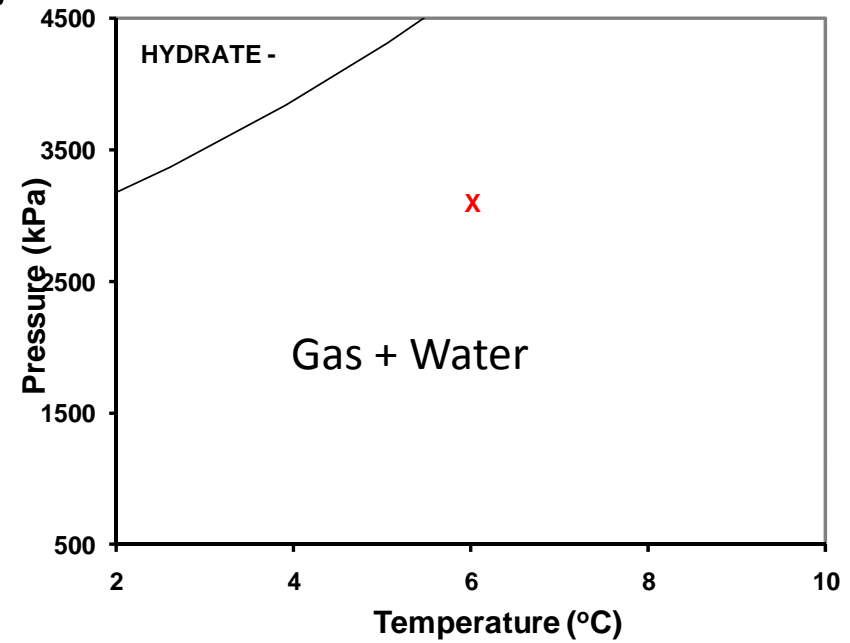
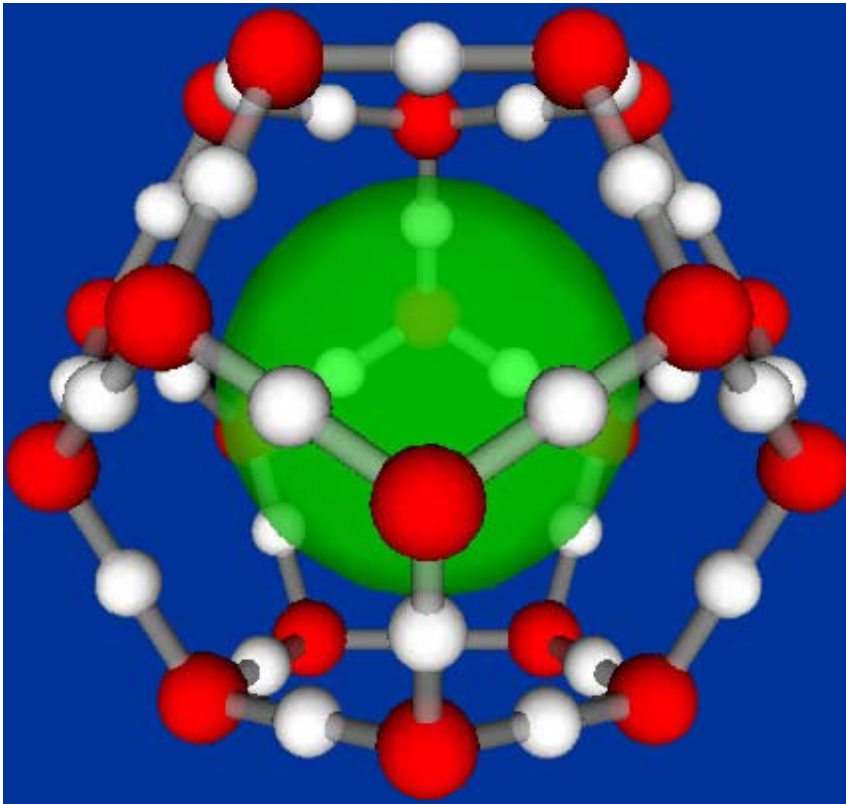
- Wright et al. 2008
 - 62 depleted gas pools
 - Capacity for many years of oil sands emissions
- “Considerable work remains ...”



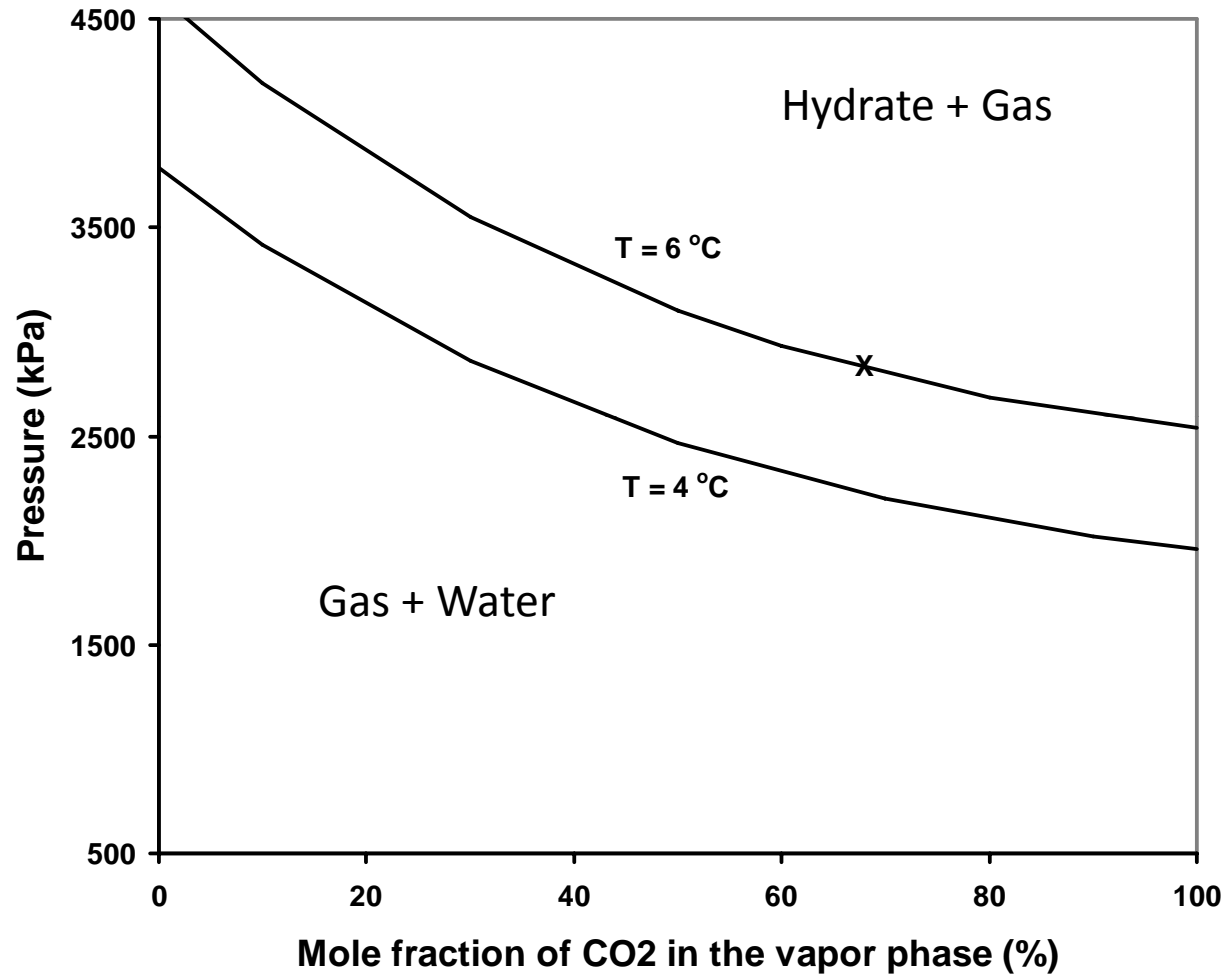
Potential advantages

- Distributed vs. centralized
- Small scale vs. large scale
- More understanding of the cap-rock and reservoir
- Easy to monitor – it is contained
- Store in solid form
 - Unless heated

Gas Hydrate?



Effect of Gas Composition



- CO₂ ↑: Pressure ↓ (T: constant)
- Heat of formation: 60 KJ/mole needs to be dissipated



Controls on Capacity

- 1 m³ of hydrate \cong 150 (std) m³ of CO₂
 - 2 MPa (gas) + 15 MPa (solid)
 - 4 MPa (gas) + 15 MPa (solid)
- Requires water
 - 1 m³ of water \cong 1.2 m³ of Hydrate
- Water: could become the limiting factor
 - If heat could be dissipated

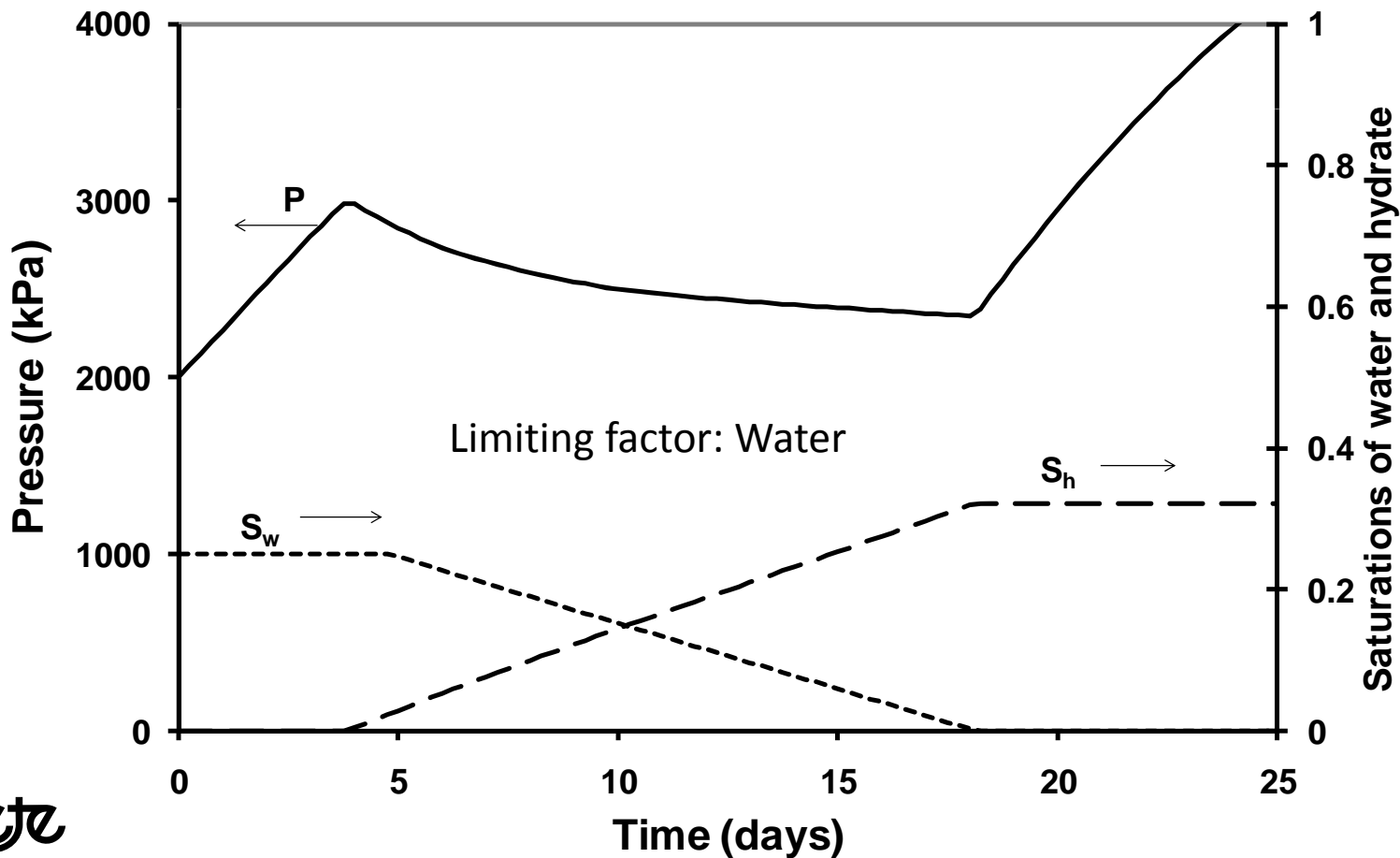
Modeling Studies (with STARS of CMG)

- Mixing Vessel – Isothermal
- Mixing Vessel – Non-isothermal
- Reservoir modeling

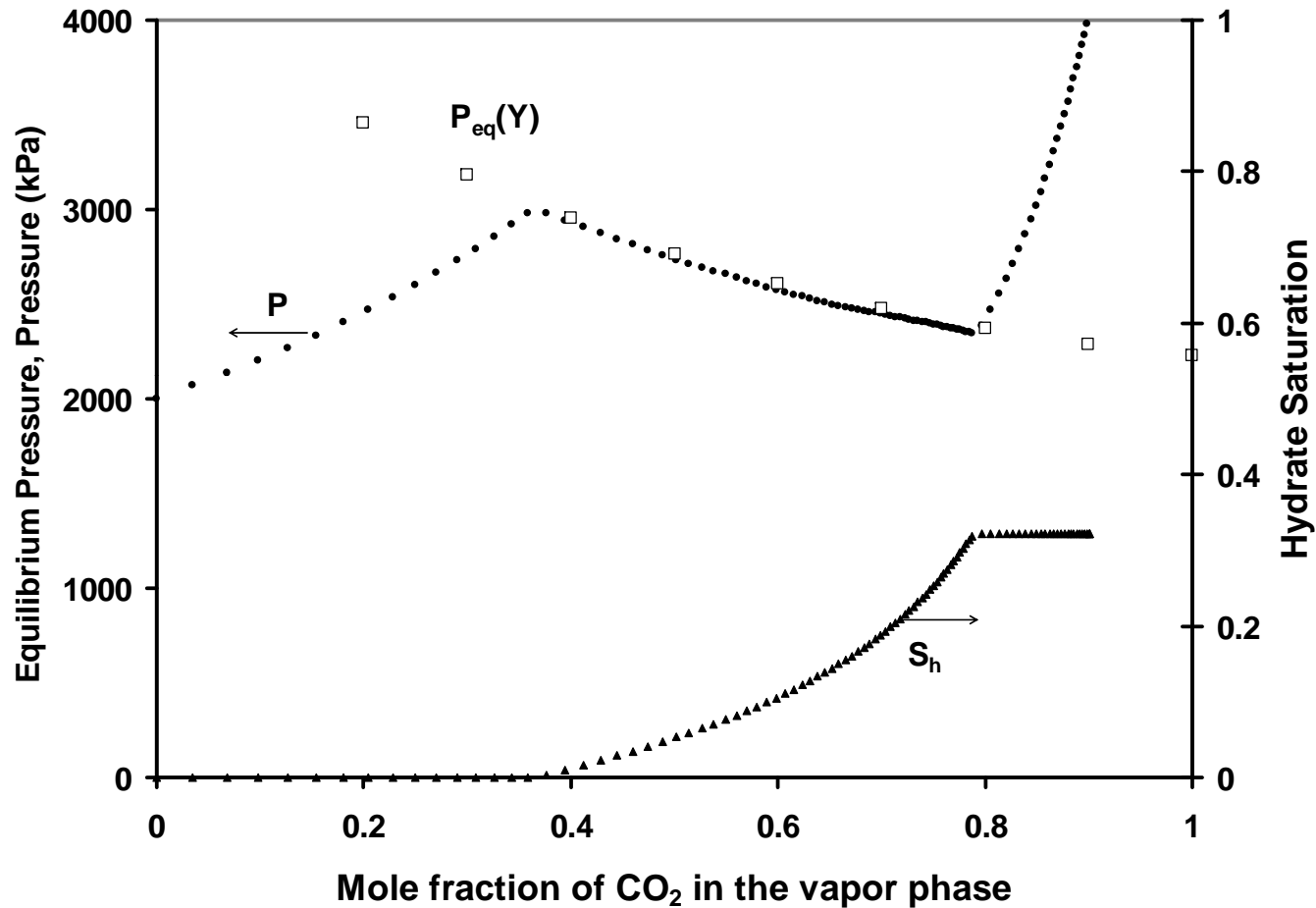
MIXING VESSEL - ISOTHERMAL

Mixing Vessel - isothermal

- Pressure: 2 MPa
- Temperature: 5 °C
- Porosity: 30%
- S_w : 25%
- Final P: 4 Mpa
- Inject at constant rate



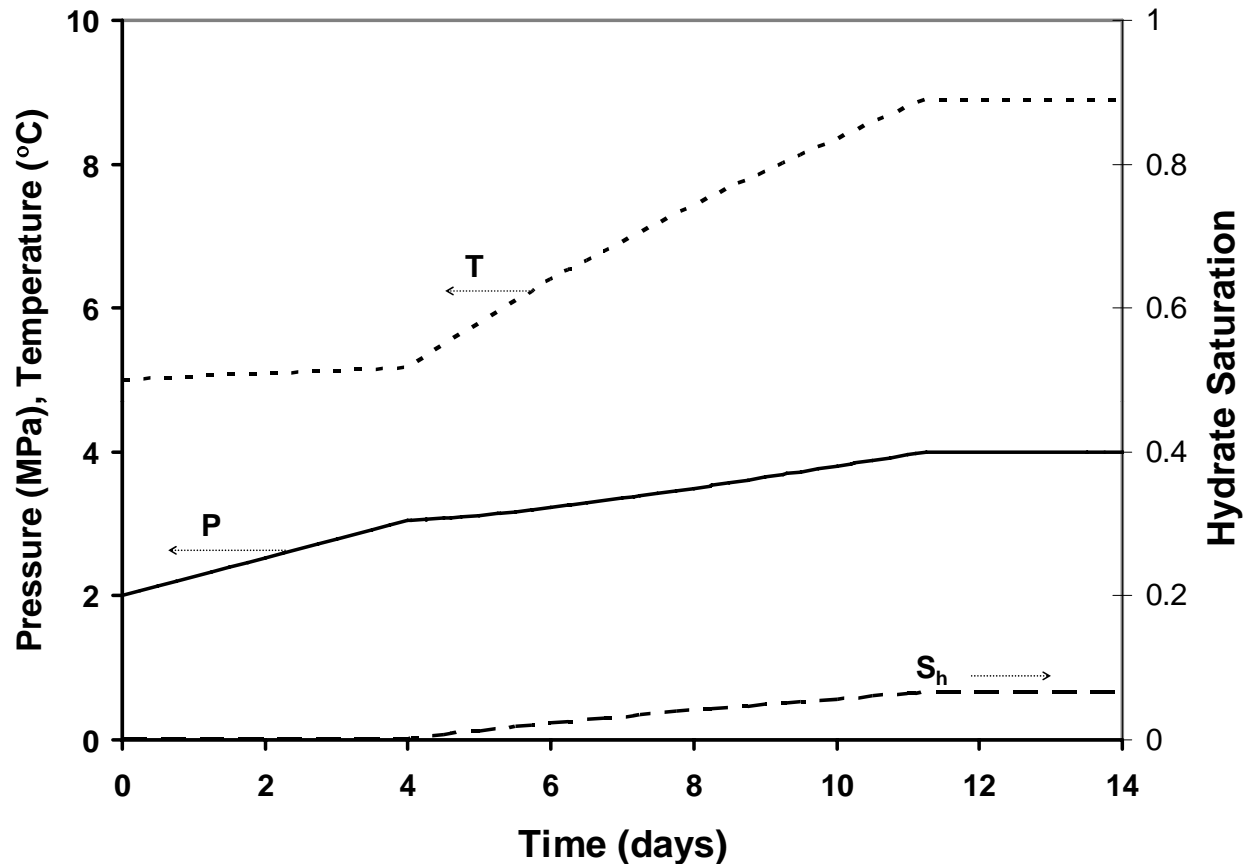
Mixing Vessel - isothermal



- Injected gas: 350% of OGIP
- Increase in pressure: 20%

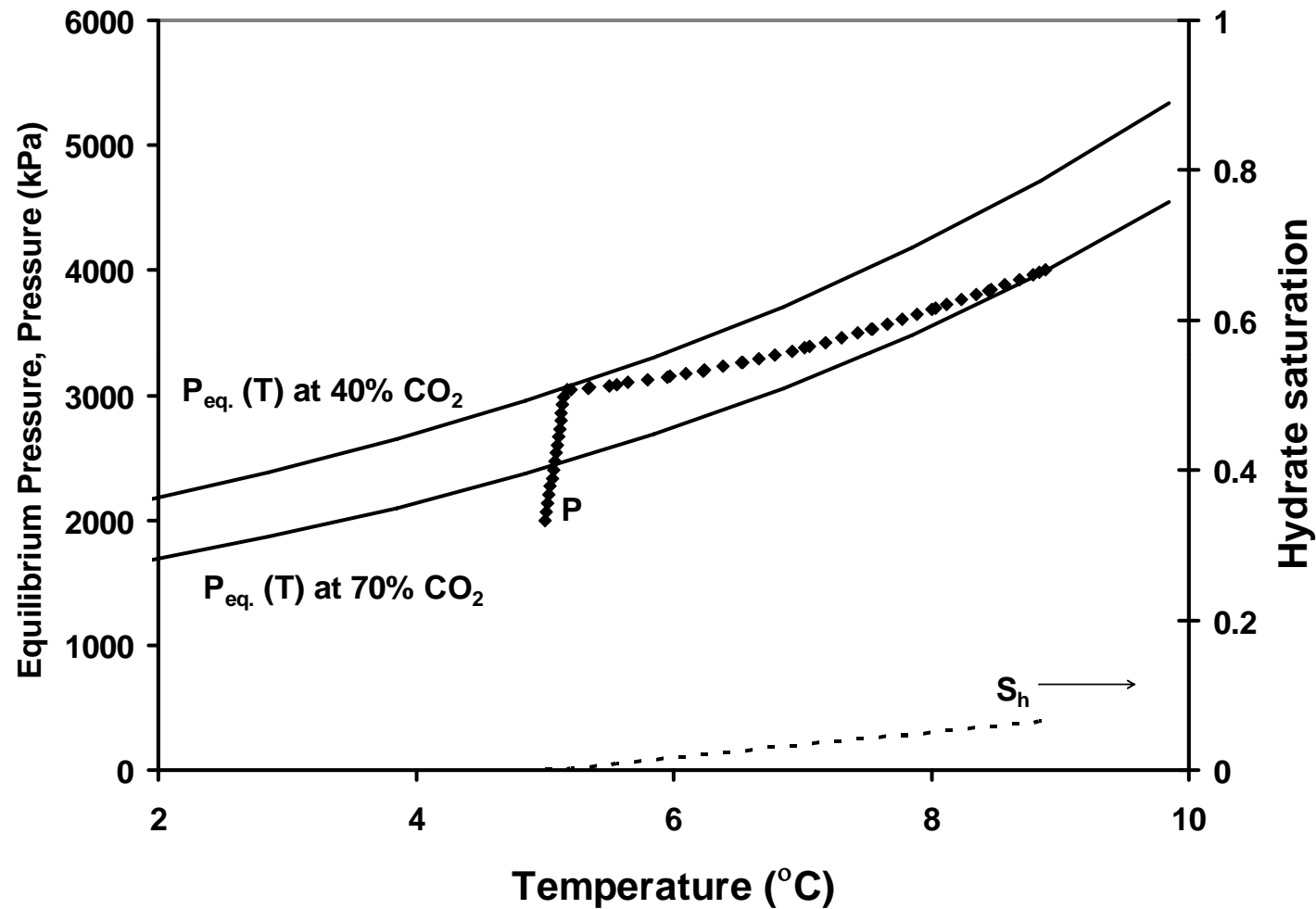
MIXING VESSEL – NON-ISOTHERMAL

Mixing Vessel – Non-isothermal



- T and p increase
- Slope of pressure increase: declines
- Final hydrate saturation: 6%

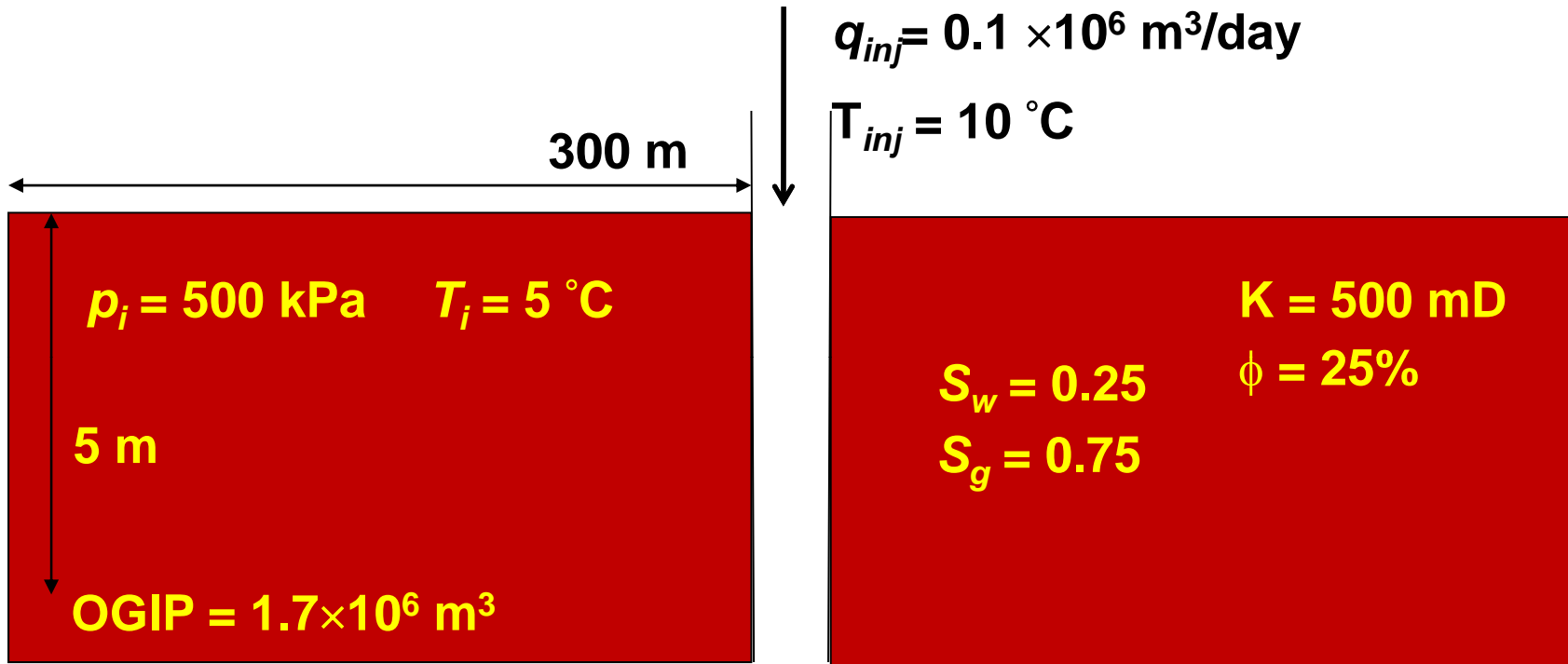
Mixing Vessel – Non-isothermal



- Limiting factor: Heat capacity

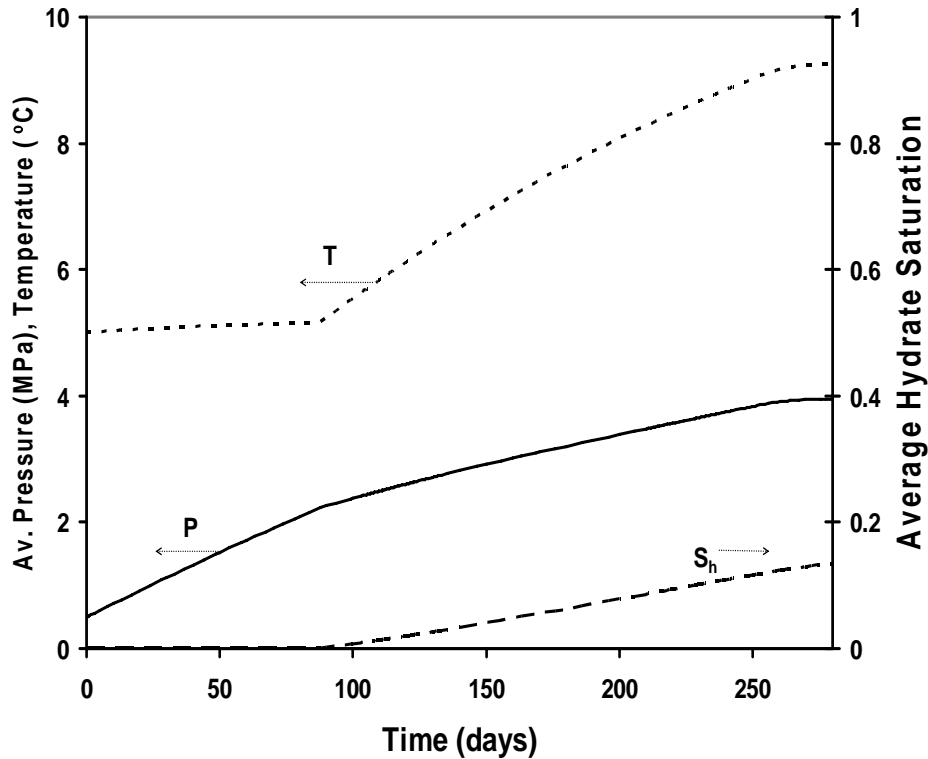
RESERVOIR MODELING

Base Case

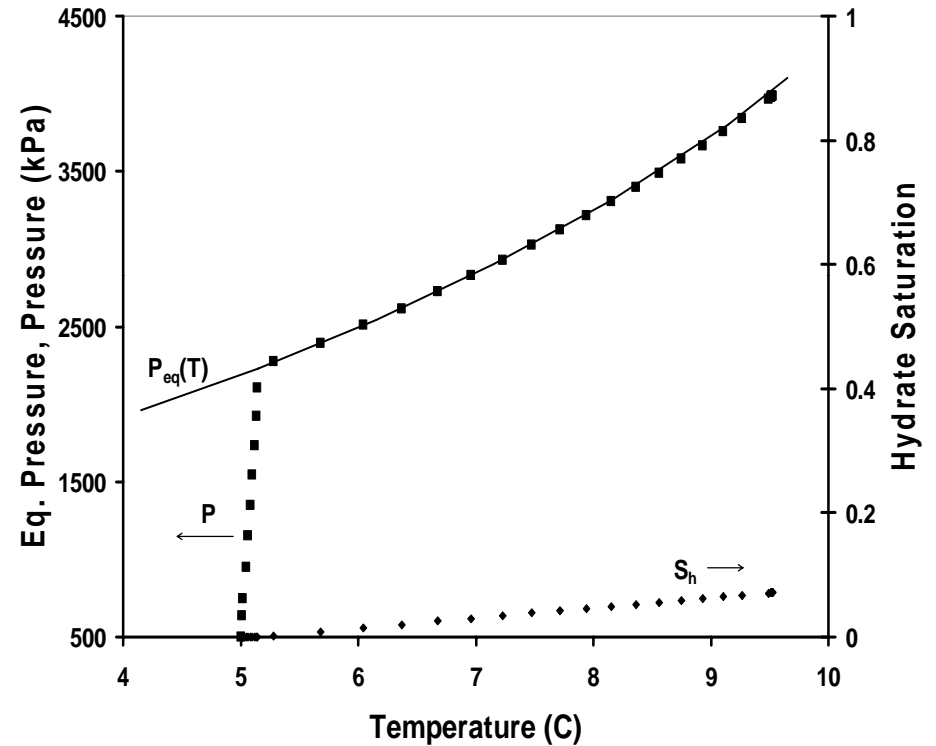


Results

Average T/p/S_H



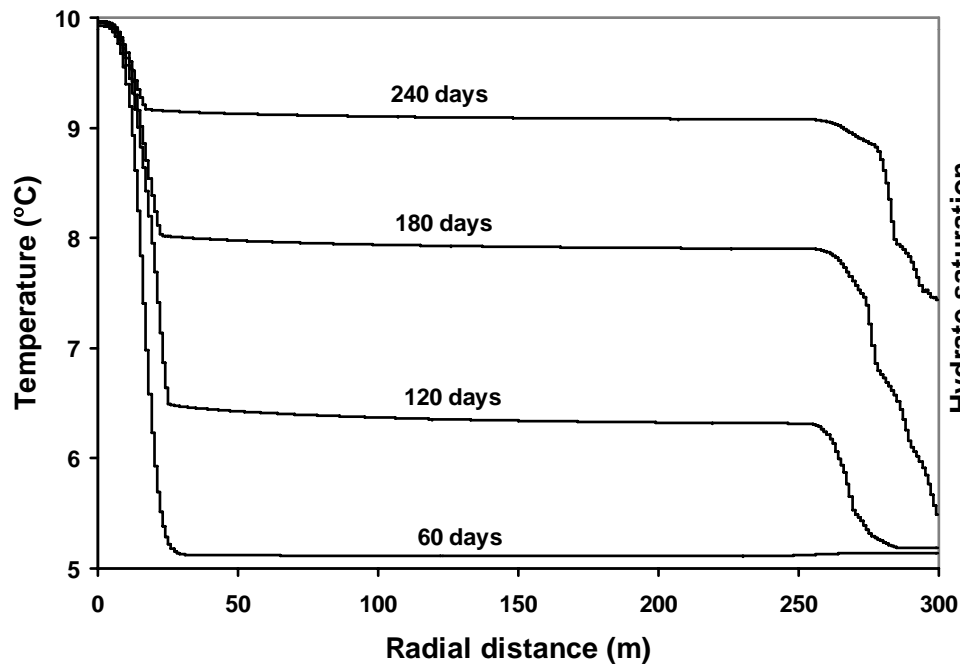
T/p on Phase diagram



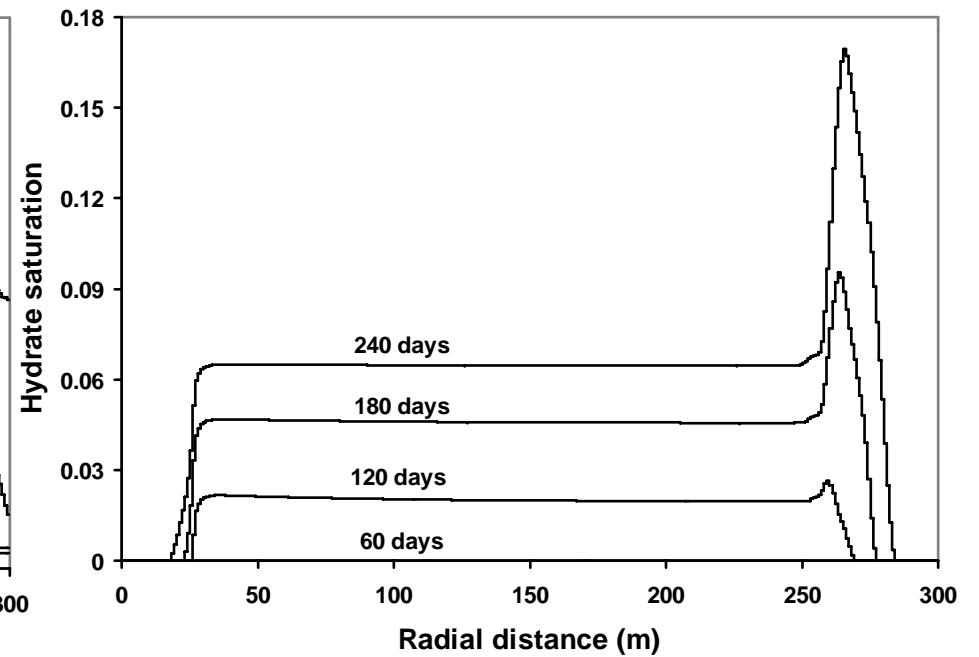
- Injected gas: 1500% of OGIP

Results

Temperature



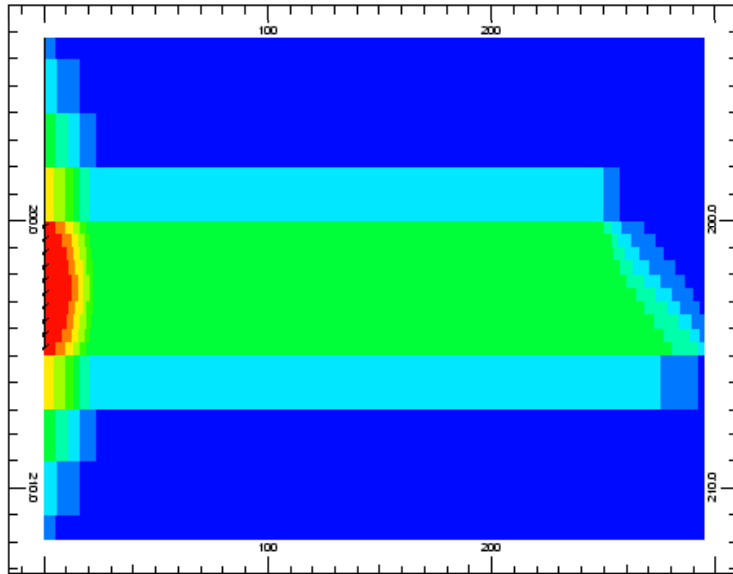
Hydrate Saturation



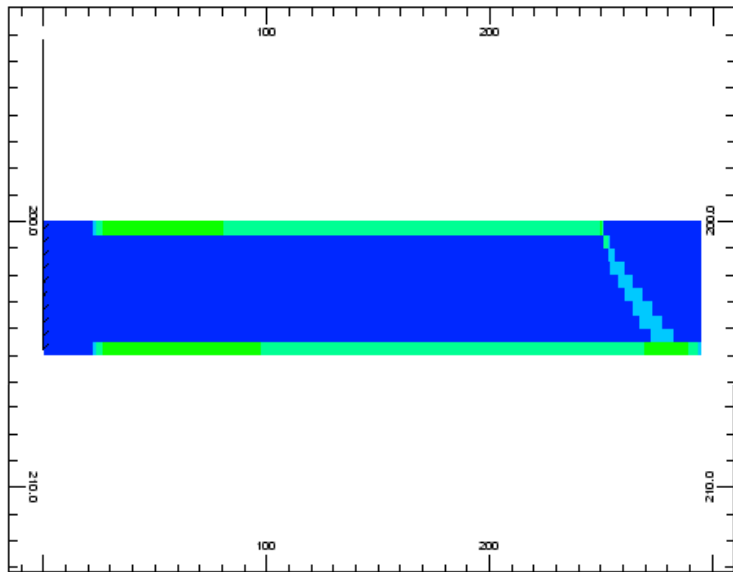
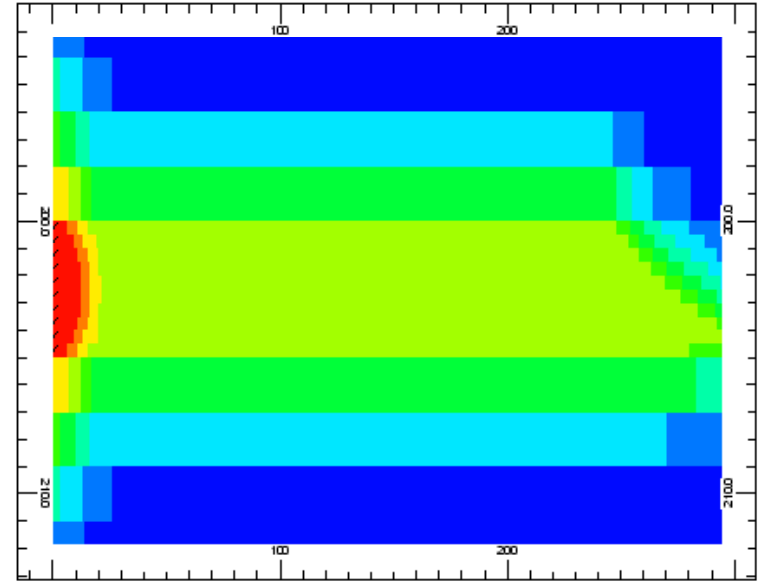
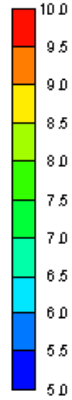
Results

180 Days

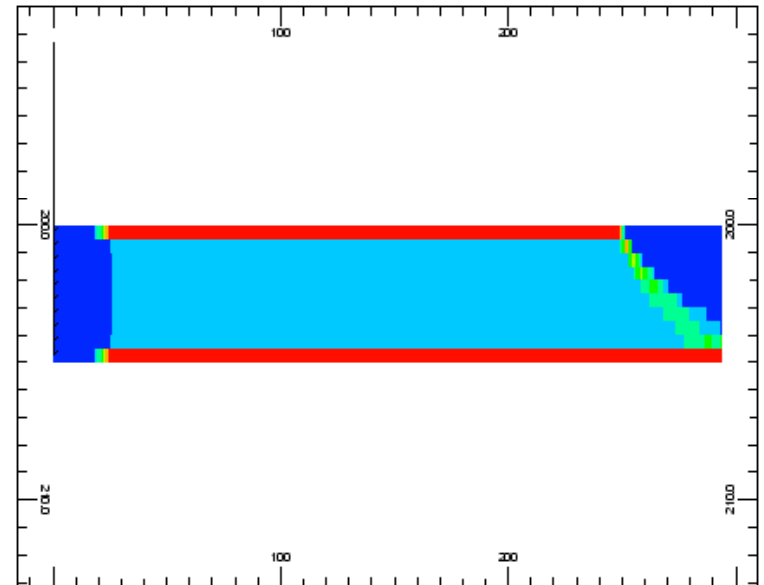
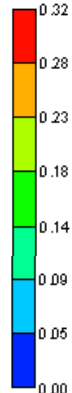
240 Days



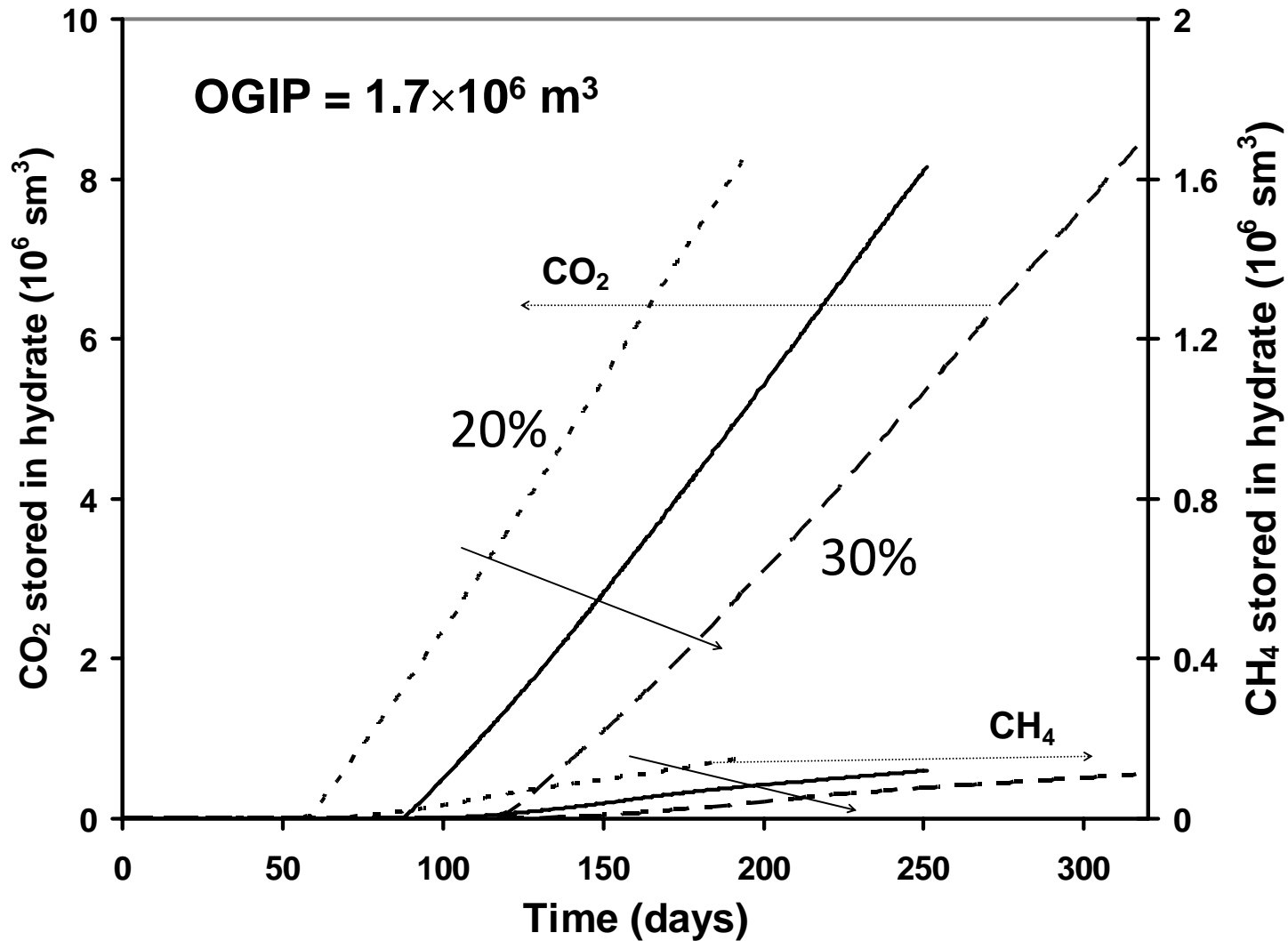
Temperature



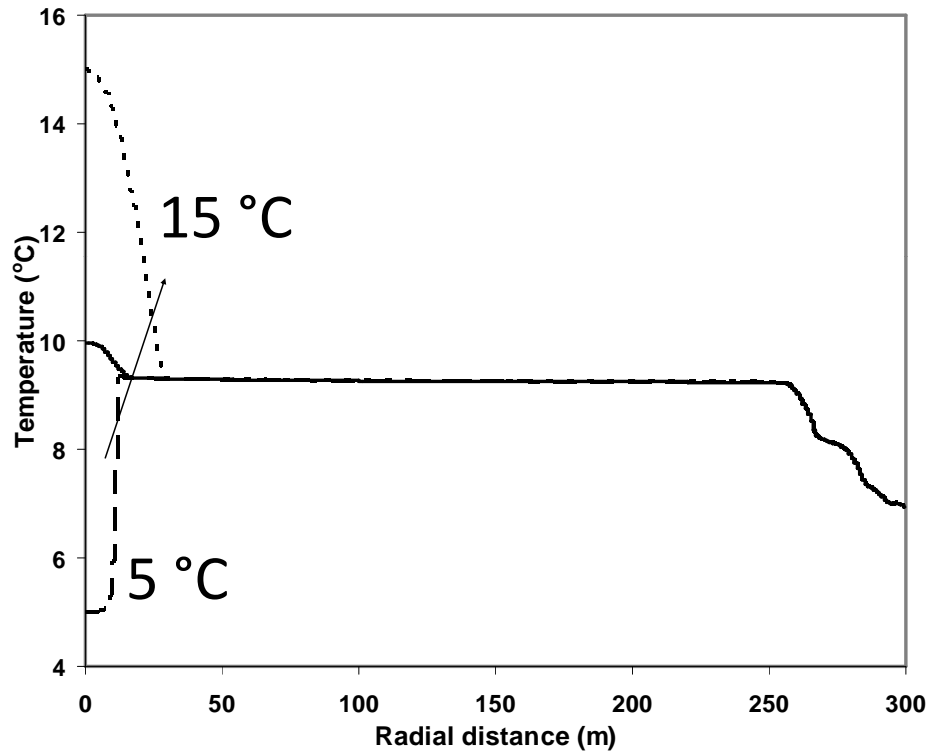
Hydrate Saturation



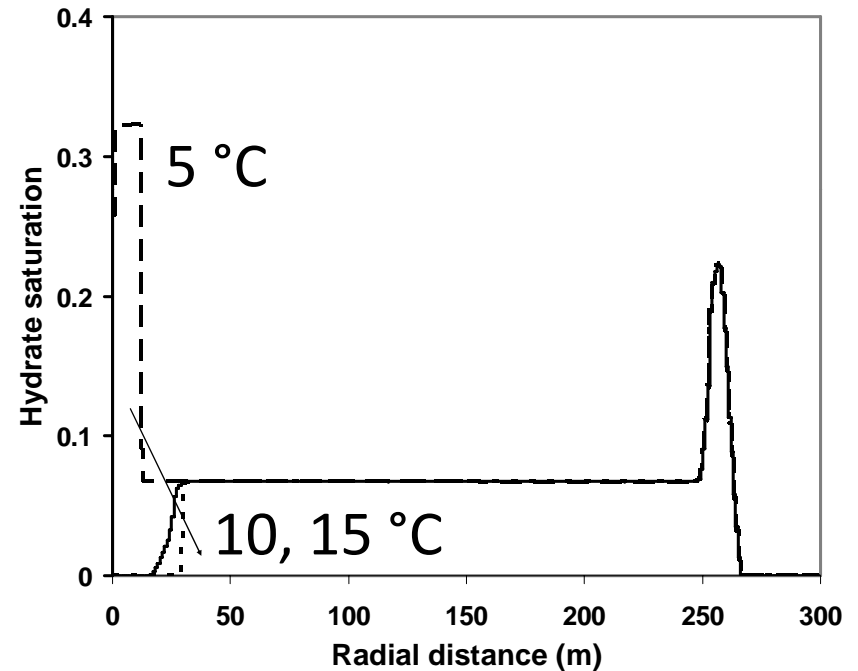
Effect of Porosity



Effect of Injection Temperature

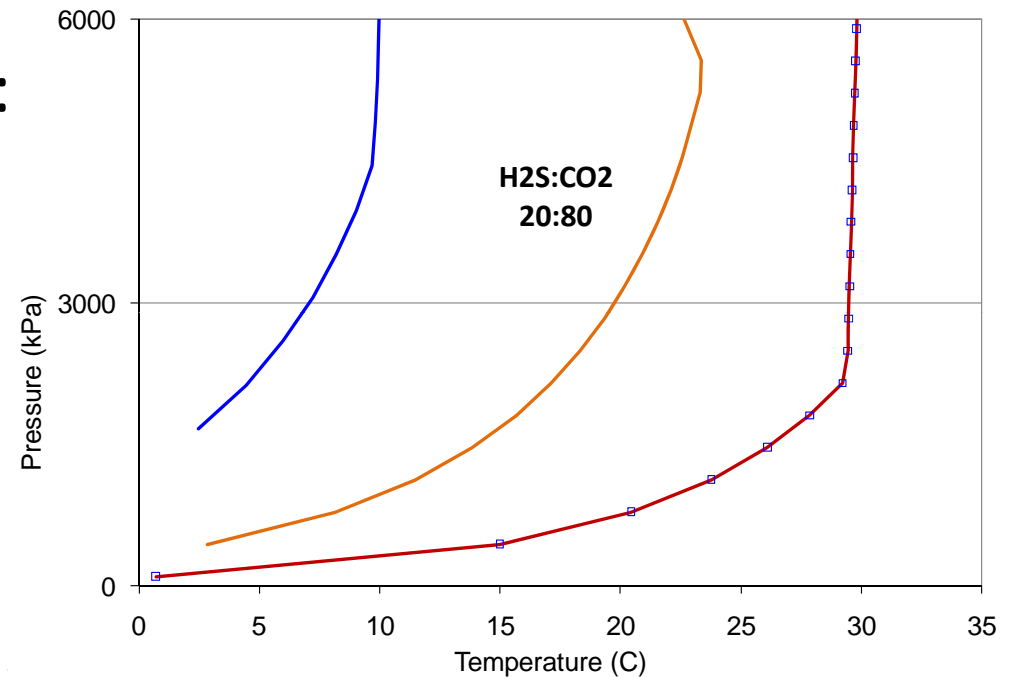


Formation Plugging



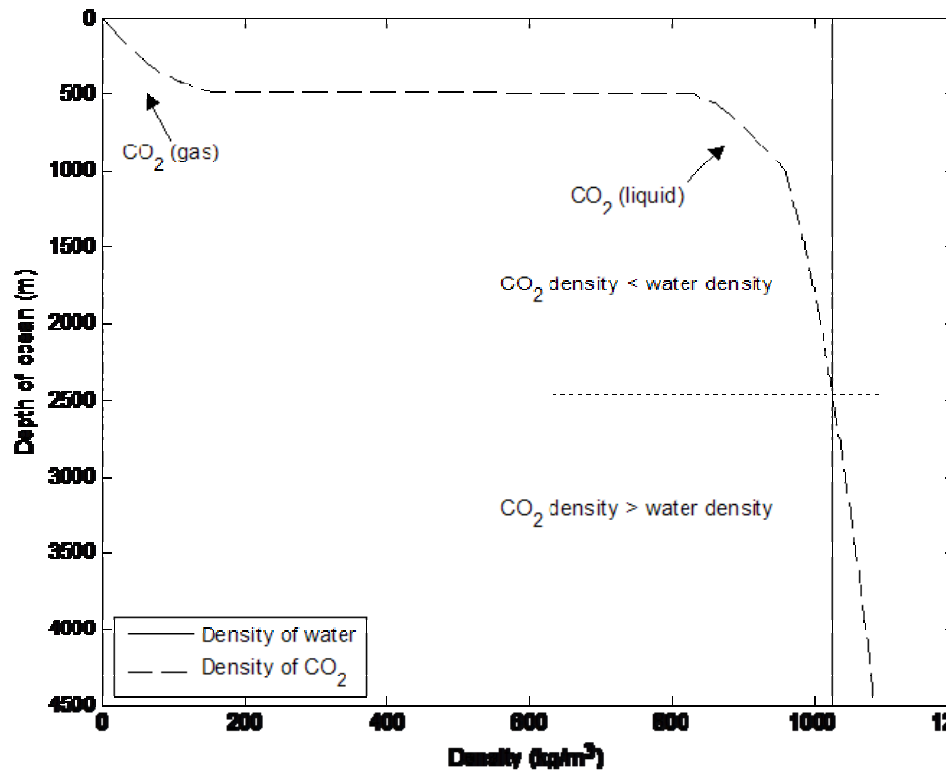
Next

- With time, heat dissipates:
T/p ↓
- Mixed Gases
(C2/C3, H₂S/SO₂)
- Effect of salinity
- Geological work
(non-SAGD-able reservoirs)

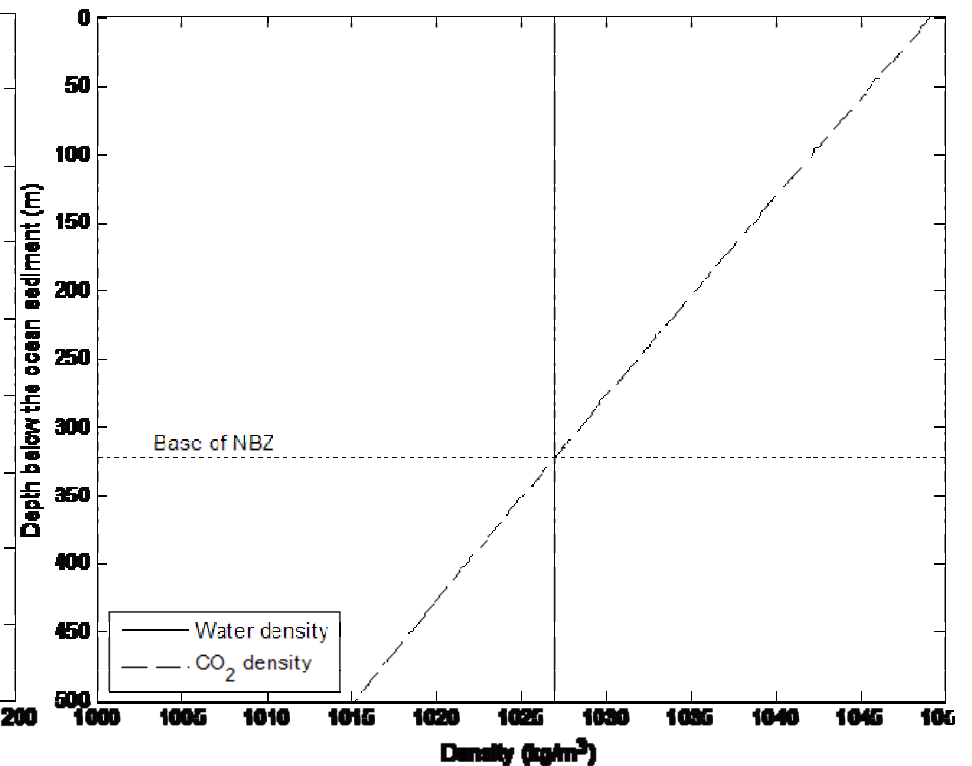


Storing CO₂ Beneath the Oceanfloor

CO₂ density within the water column



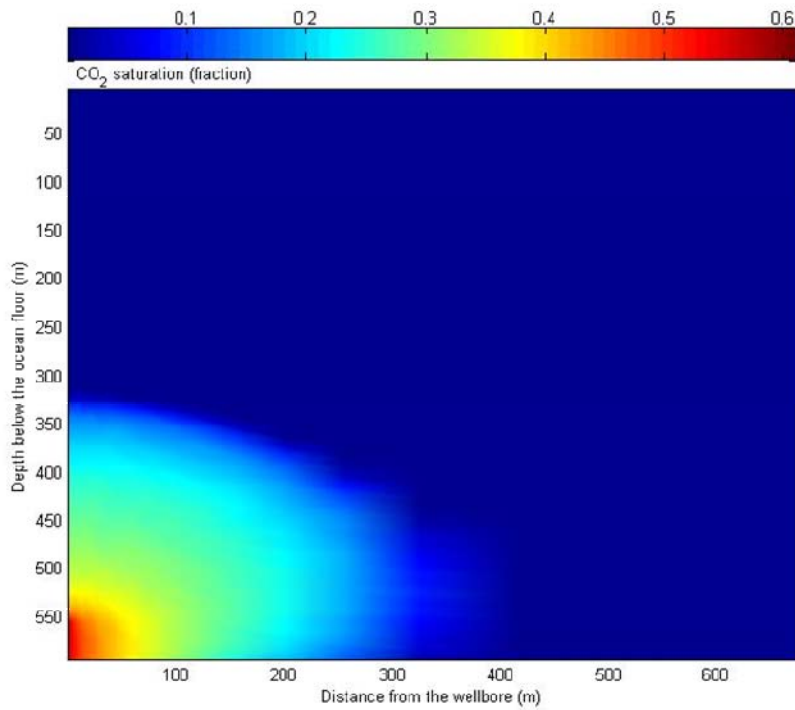
CO₂ density beneath the ocean floor



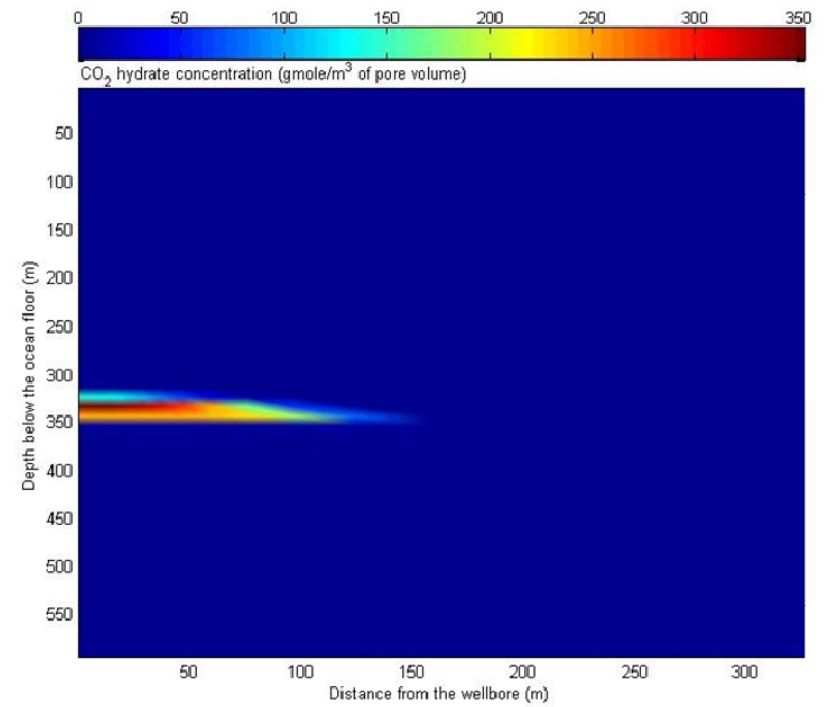
Negative Buoyancy zone

Simulation Results (50 years)

CO₂ Saturation (gas)

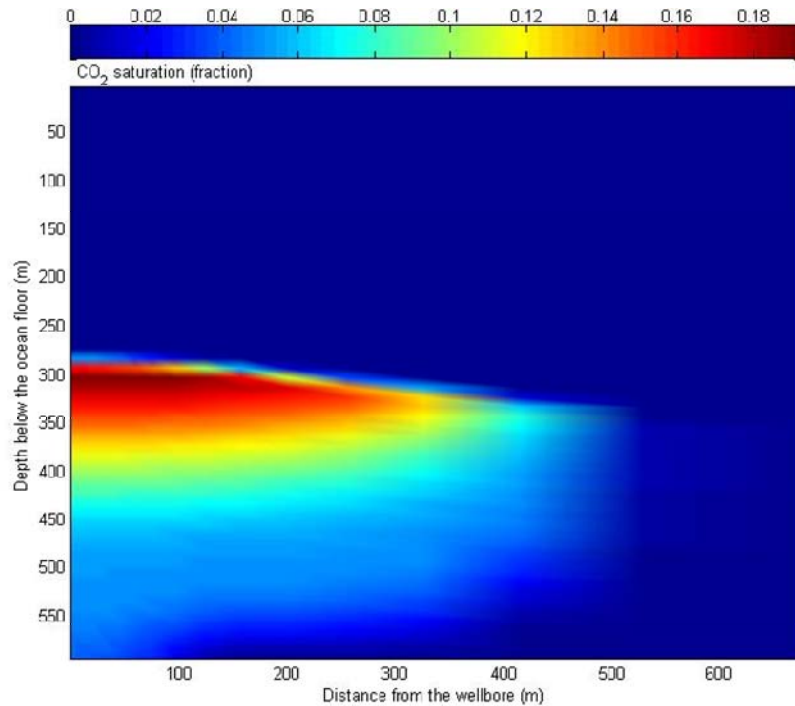


Hydrate Concentration

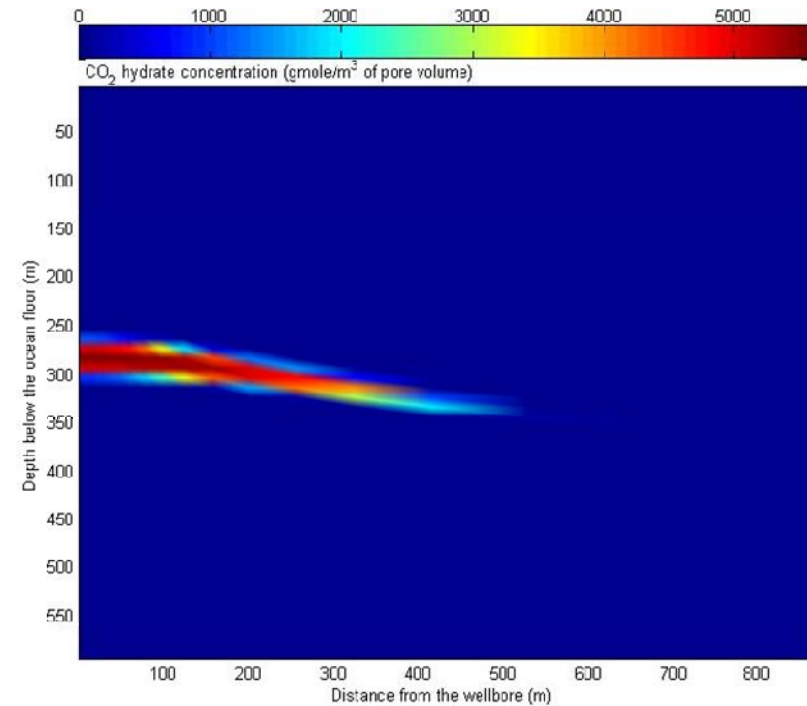


Simulation Results (500 years)

CO₂ Saturation (gas)



Hydrate Concentration



Acknowledgment

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- NSERC for funding
- Chem/Pet Department and Fekete for their support

THANK YOU!

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Fekete

