U N I V E R S I T Y O F B E R G E N

Institute of Physics and Technology

Hydrate Formation and Gas Production from Hydrates by CO_2 Injection

By

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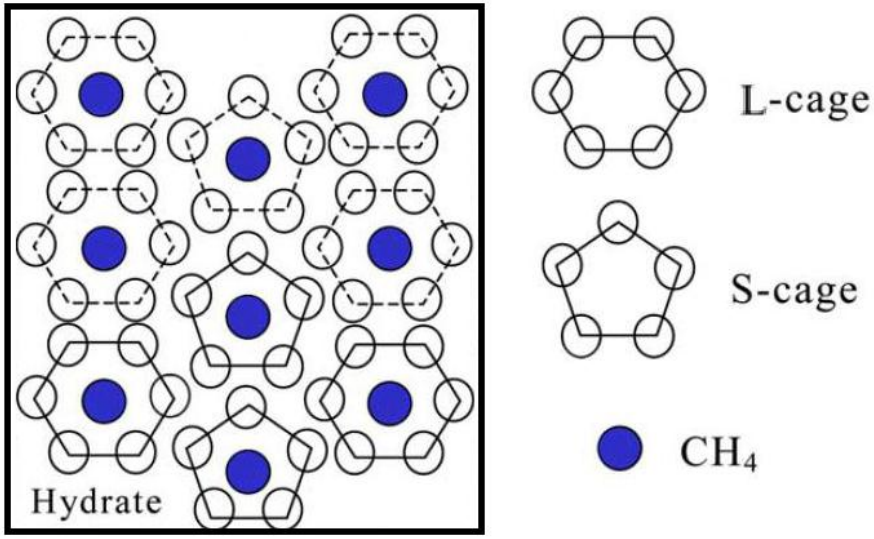
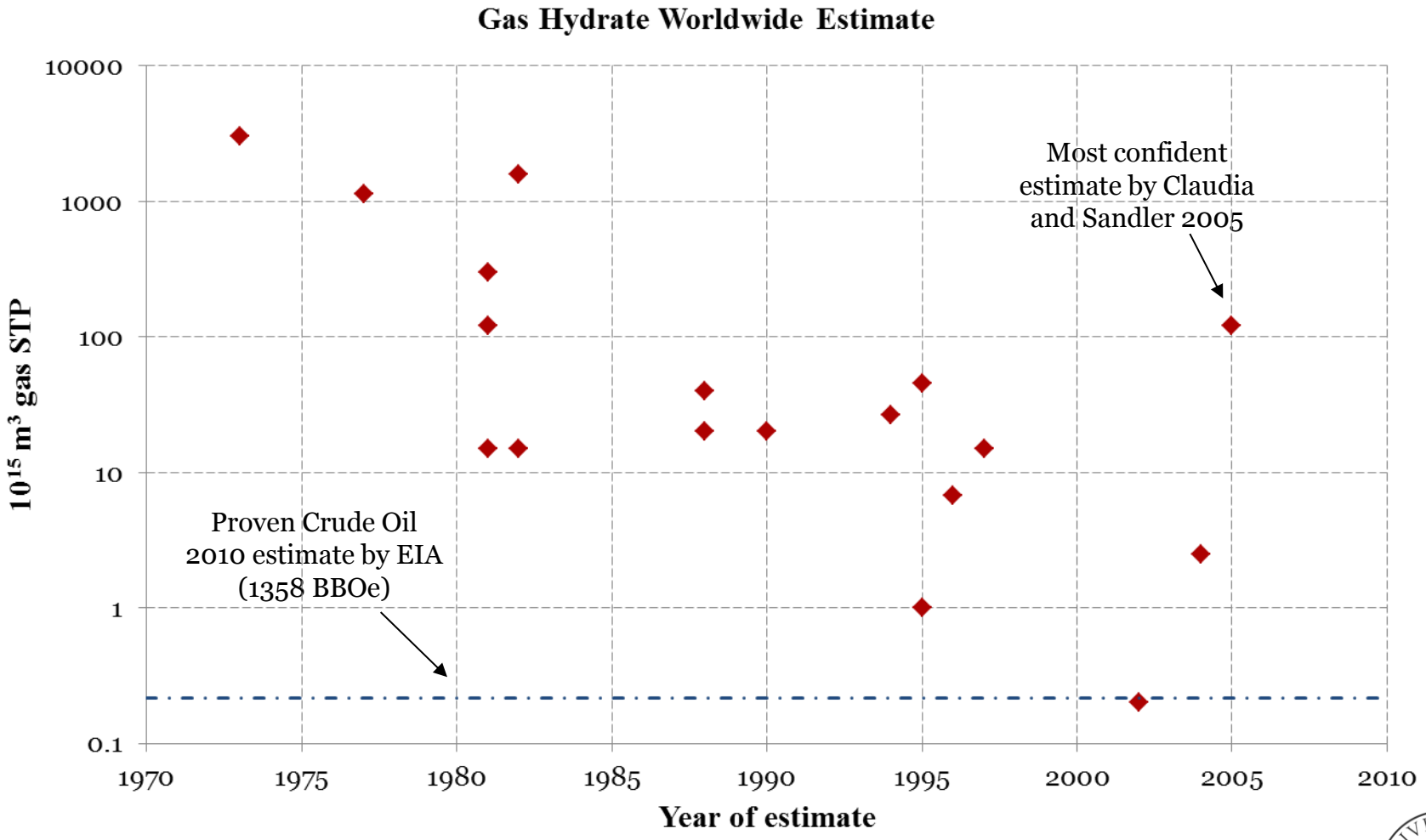
Natural gas hydrate

- Crystalized structure consisting of water and a guest molecule (e.g. methane) – resembles ice
- High pressure (>30 bar) and low temperature (<10 °C)
- Permafrost regions and off-shore



Ota et al. (2005)

Estimates of Total Gas Hydrate Amount



Hydrate
Reservoir strategies

- Production scenarios
  - Pressure reduction
  - Temperature increase
  - Chemical additive
  - Exchange with CO_2

Hydrate

Injection of CO_2 to produce methane

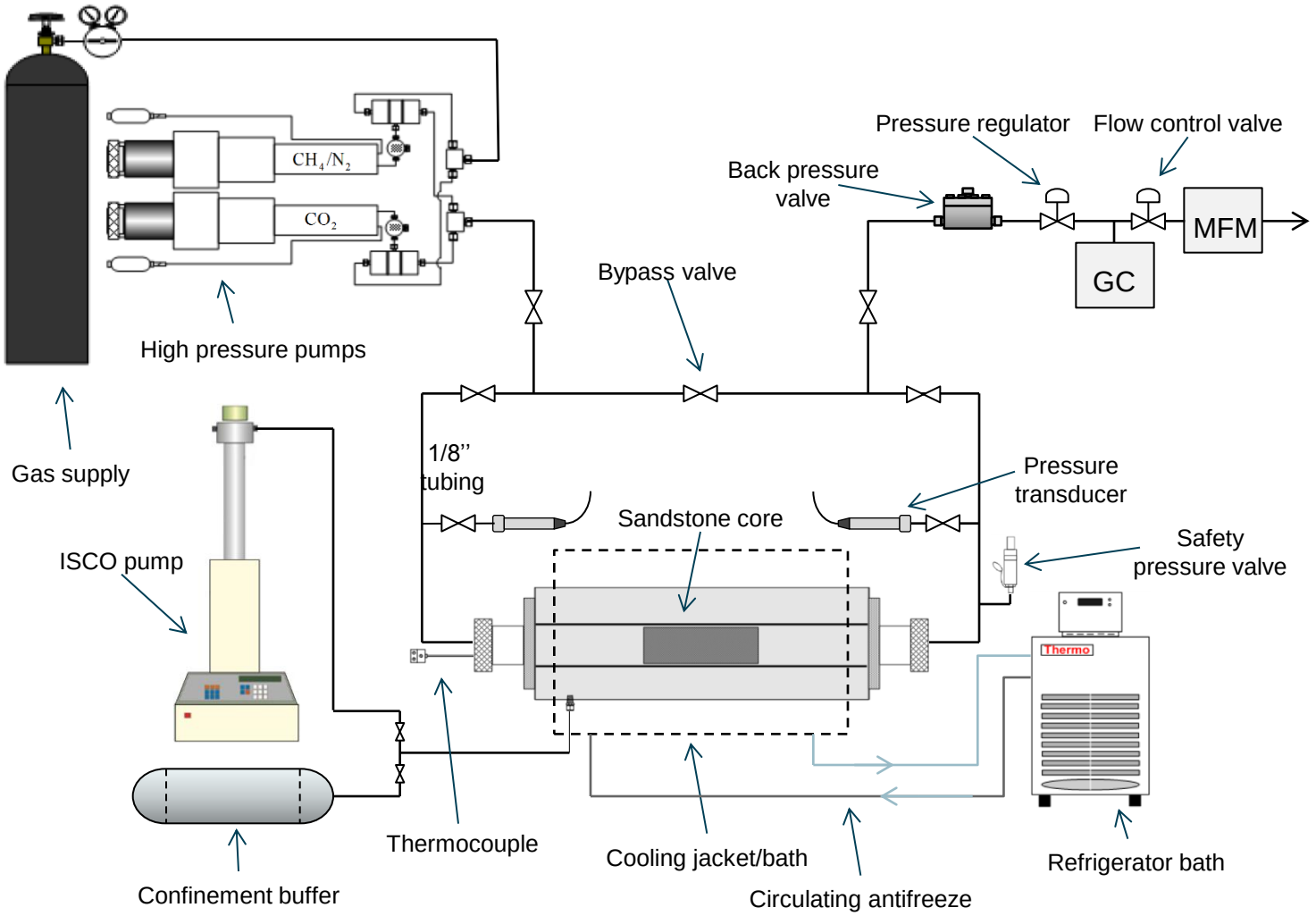
Pros

- Integrity of hydrate structure remains intact
- Sequestration of CO_2
- No temperature increase
- Increased stability

Cons

- Requires permeability
- Risk of hydrate formation from free water
- Relatively slow rate of exchange
- Investment cost

Experimental set up



Model made by Christian Hågenvik

Experimental conditions

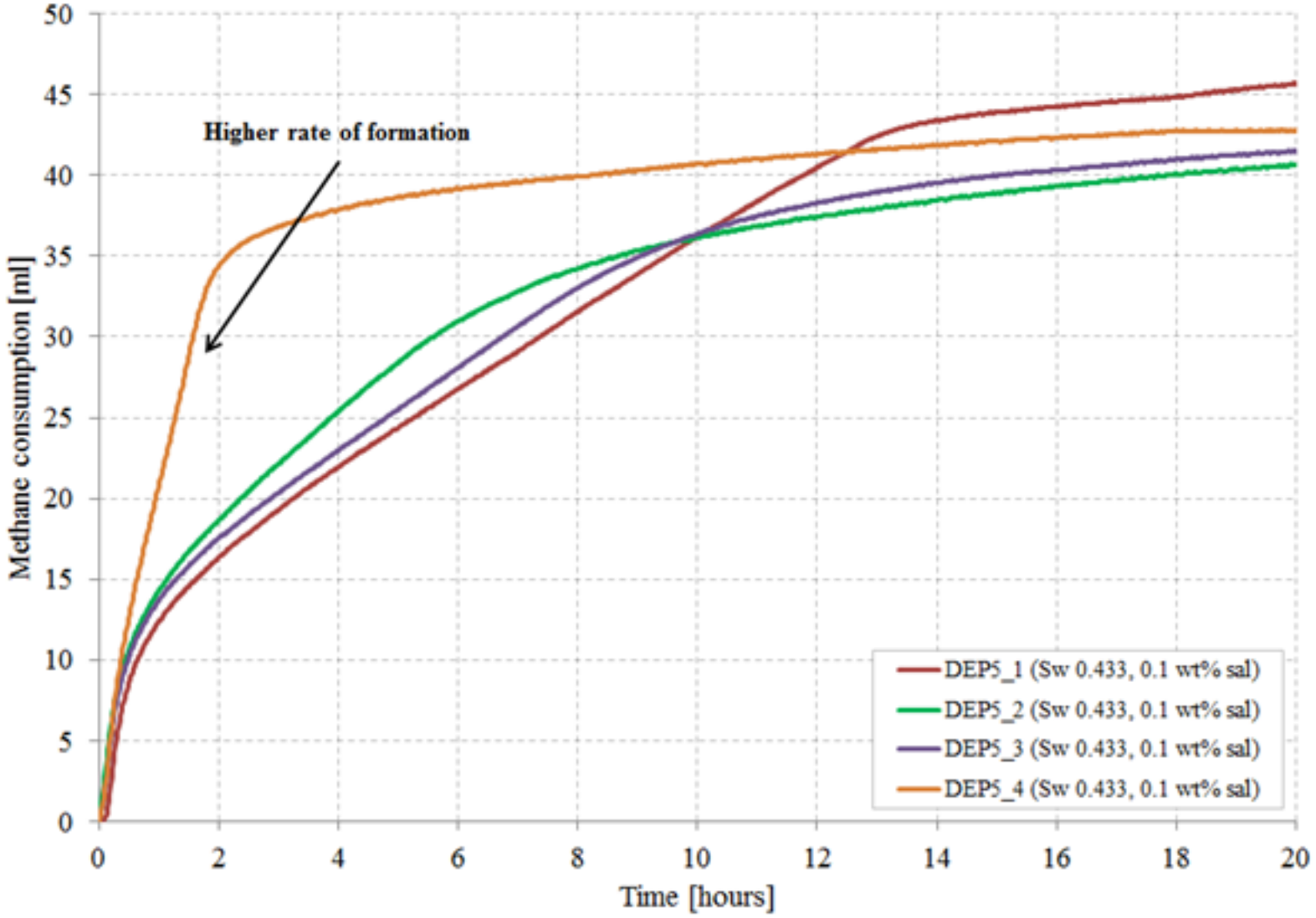
- Porous media
  - Bentheim sandstone
  - High permeable (1.1 D)
  - 20-25% porosity
  - Homogeneous (99% quartz)
- Brine saturation 0.4 – 0.7
- Brine salinity 0.1 – 3.5 wt% NaCl
- Pressurized with CH_4 to 83 barg/1200 psi
- Temperature reduced from ~23 °C to 4 °C

Methane Hydrate formation

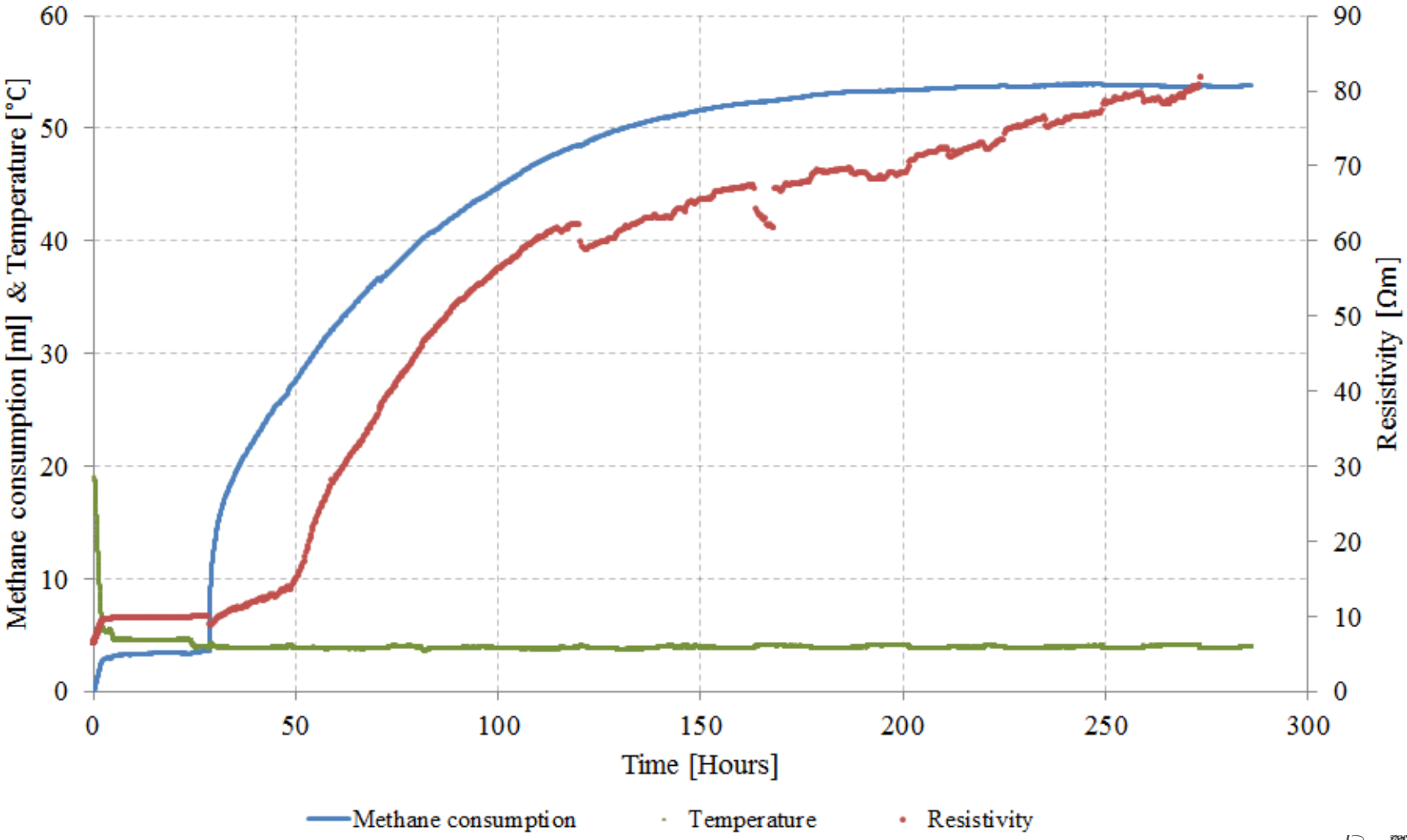
EXPERIMENTAL RESULTS

Same initial conditions

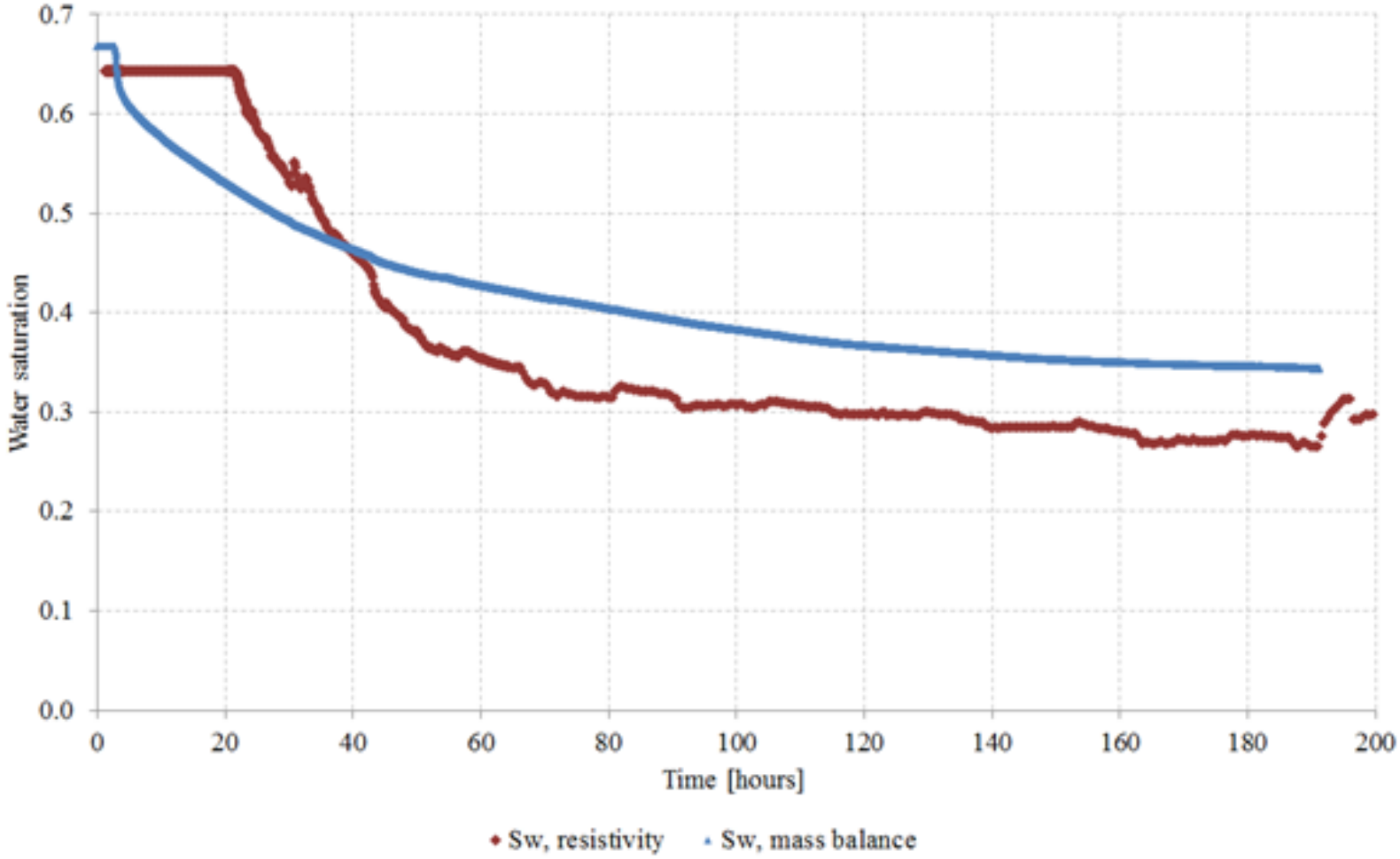
(system not dissasembled, only reformed)



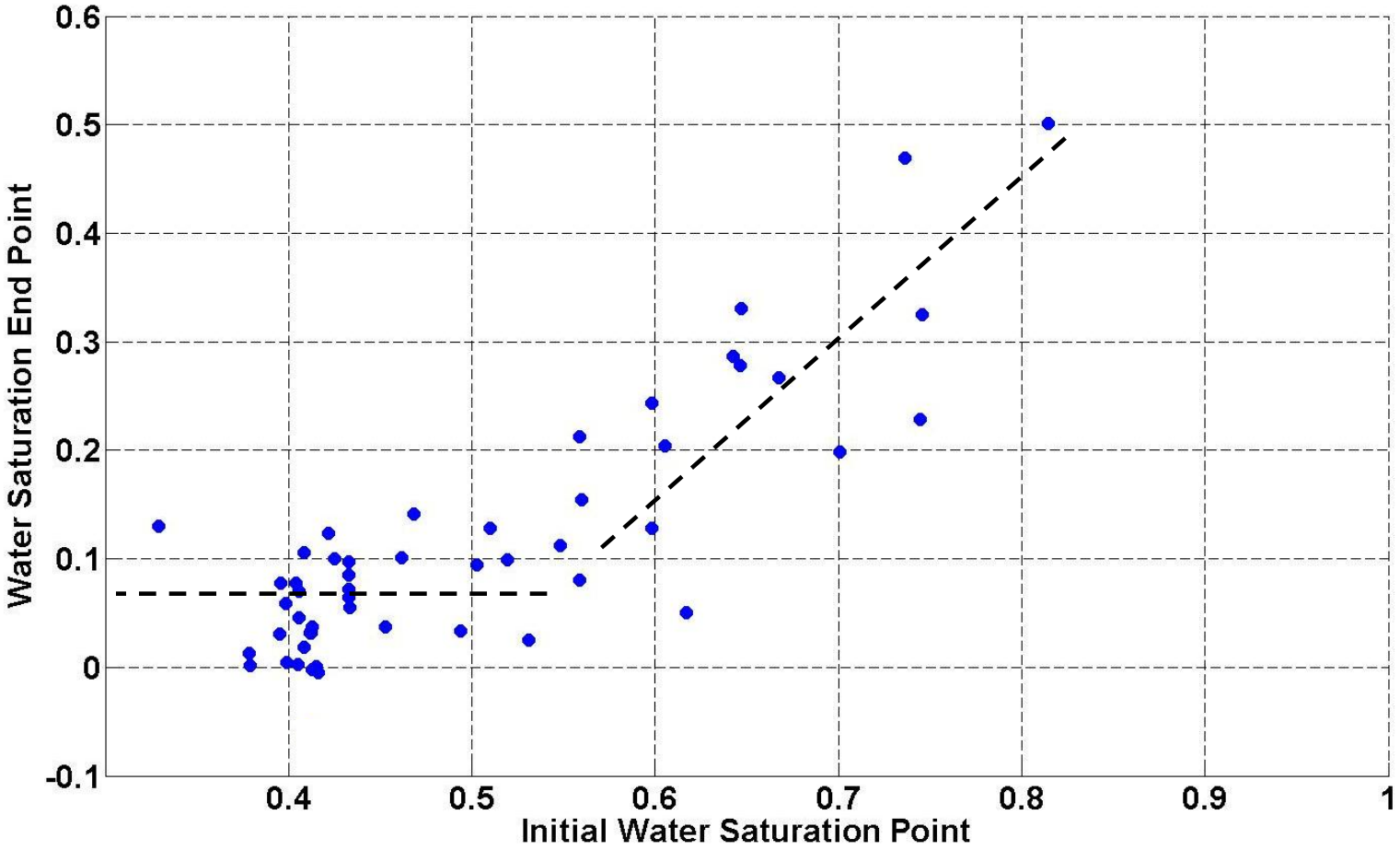
Hydrate formation



Water saturation based on mass balance and resistivity



Post Hydrate formation

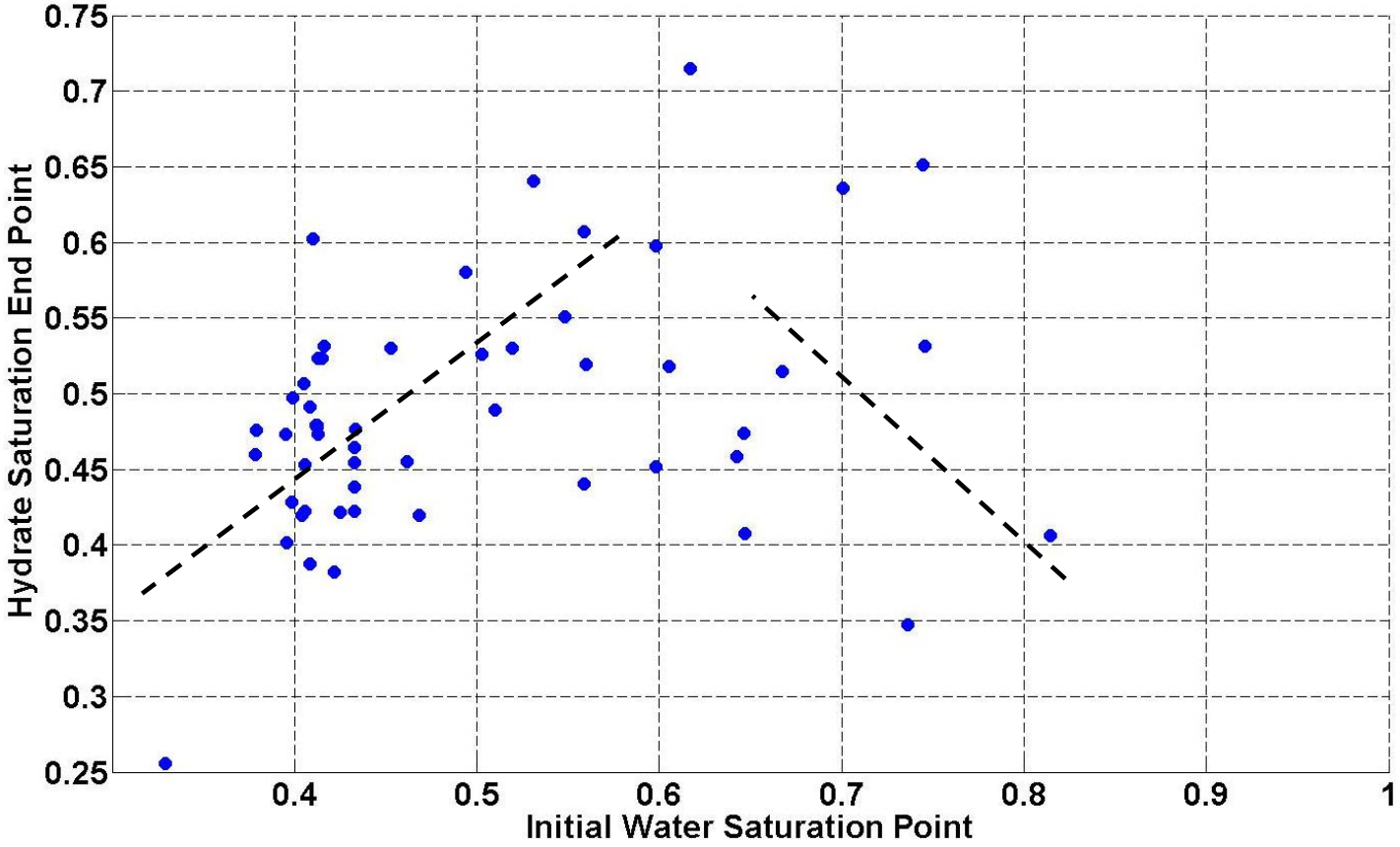


Limiting factor: lack of water

Limiting factor: Mass transport – water trapping

Post Hydrate formation

Higher hydrate saturation for Swi ≈ 0.6



Limiting factor: lack of water

Limiting factor: Mass transport – water trapping

CO_2 induced methane production

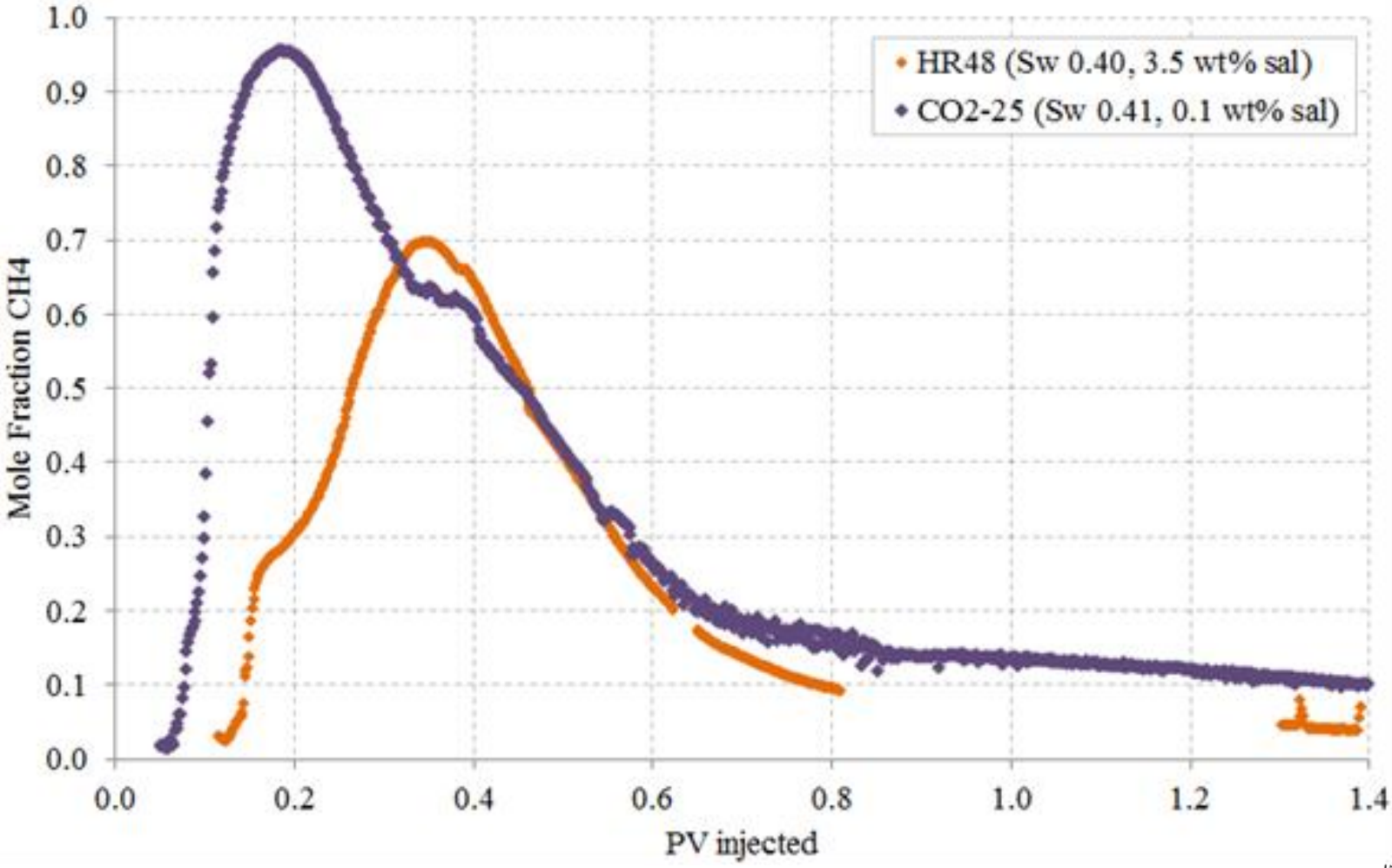
EXPERIMENTAL RESULTS

Experimental procedure

- A back pressure valve maintains constant production pressure of approximately 85 barg.
- CO_2, or a CO_2/N_2 mix, is injected at a constant flow rate of 1.2 ml/h for all experiments.
- Injection pressure, production pressure, gas fraction and mass produced is monitored and later used to calculate differential pressure and fluids produced.

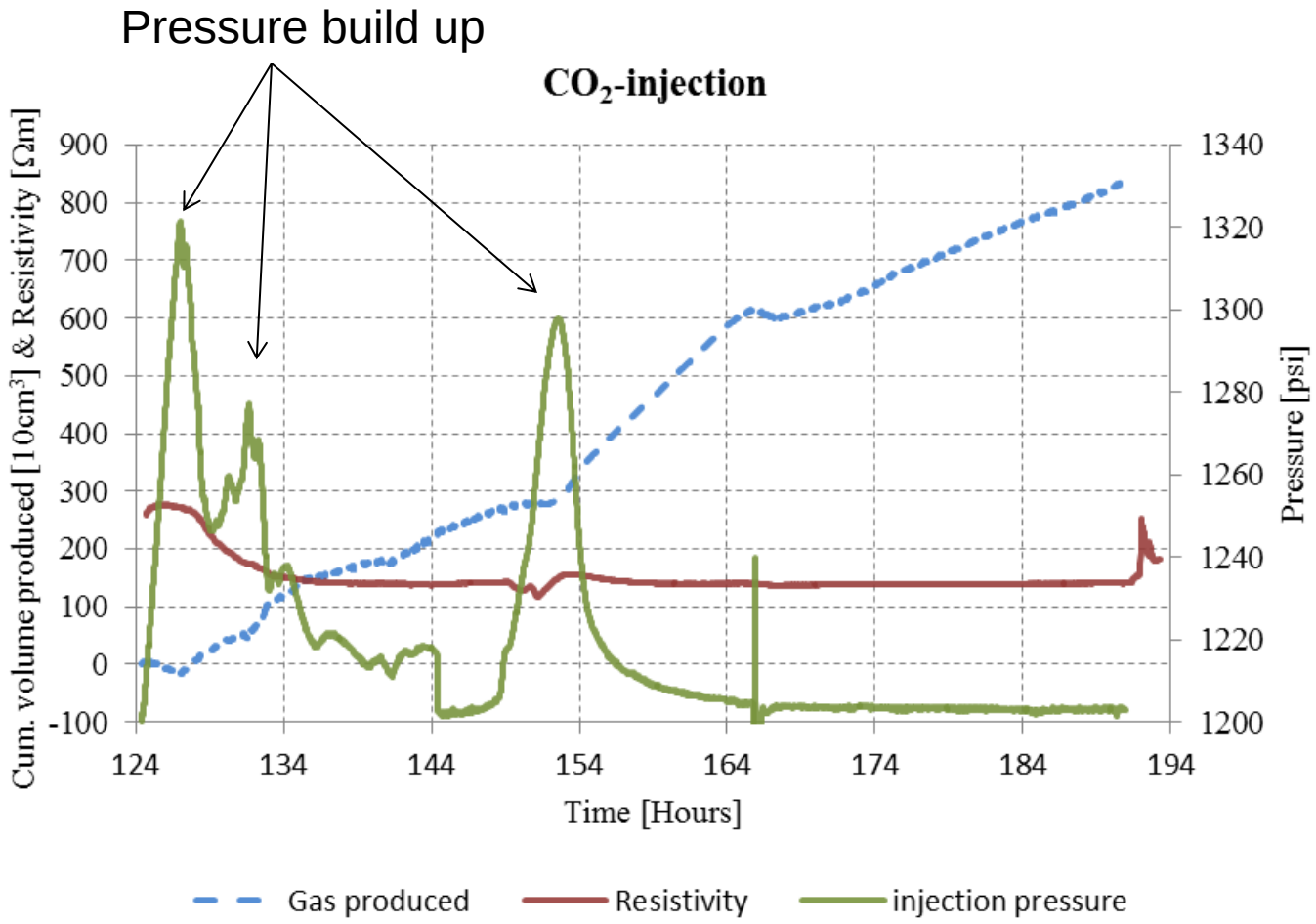
Fraction of Methane during Production

Measured by GC

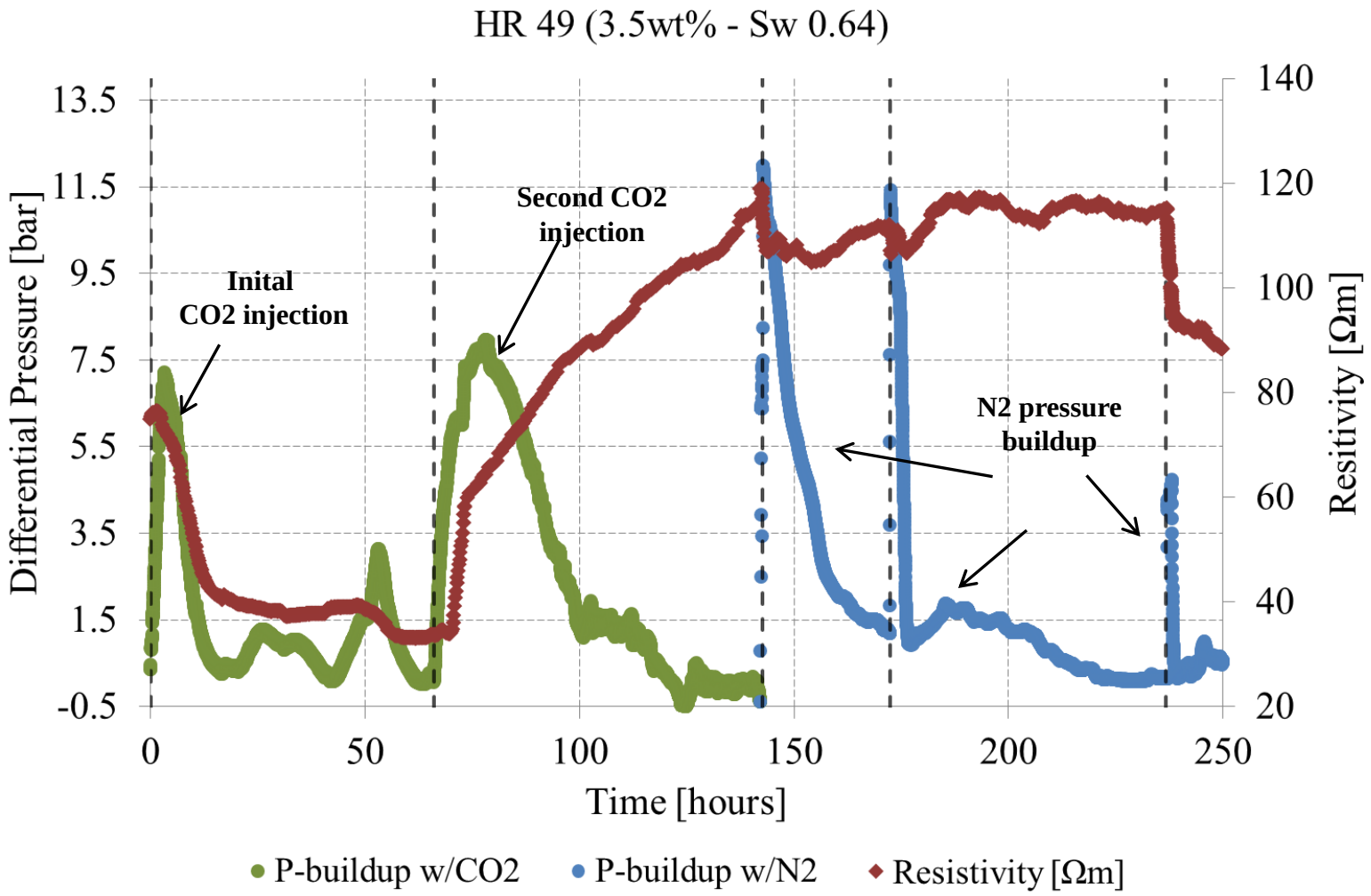


Production during CO_2 injection

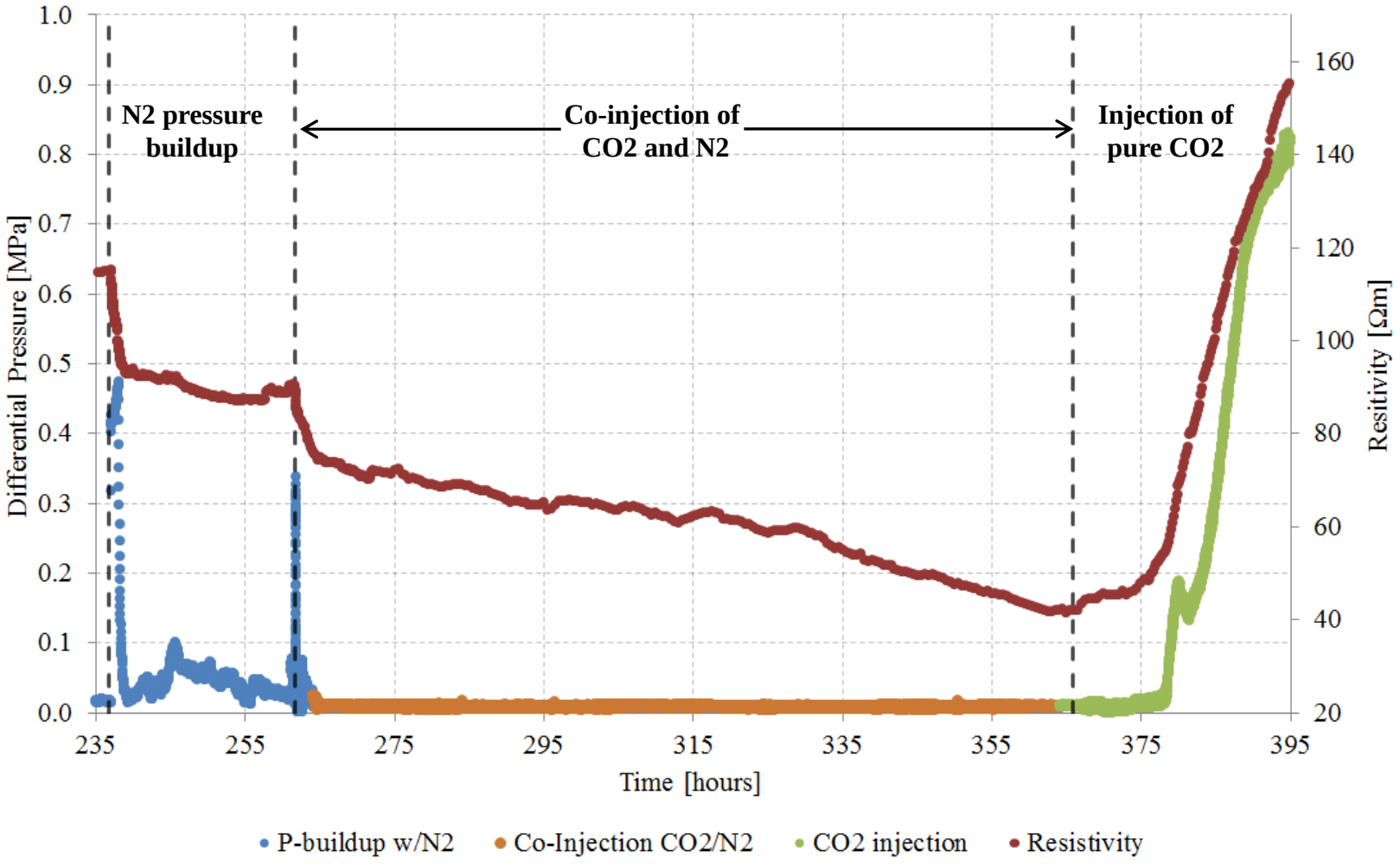
Resistivity, gas produced and differential pressure



Remediation of plugged core by use of N_2



CO-injection of CO_2 and N_2 (25/75 mol% resp.)



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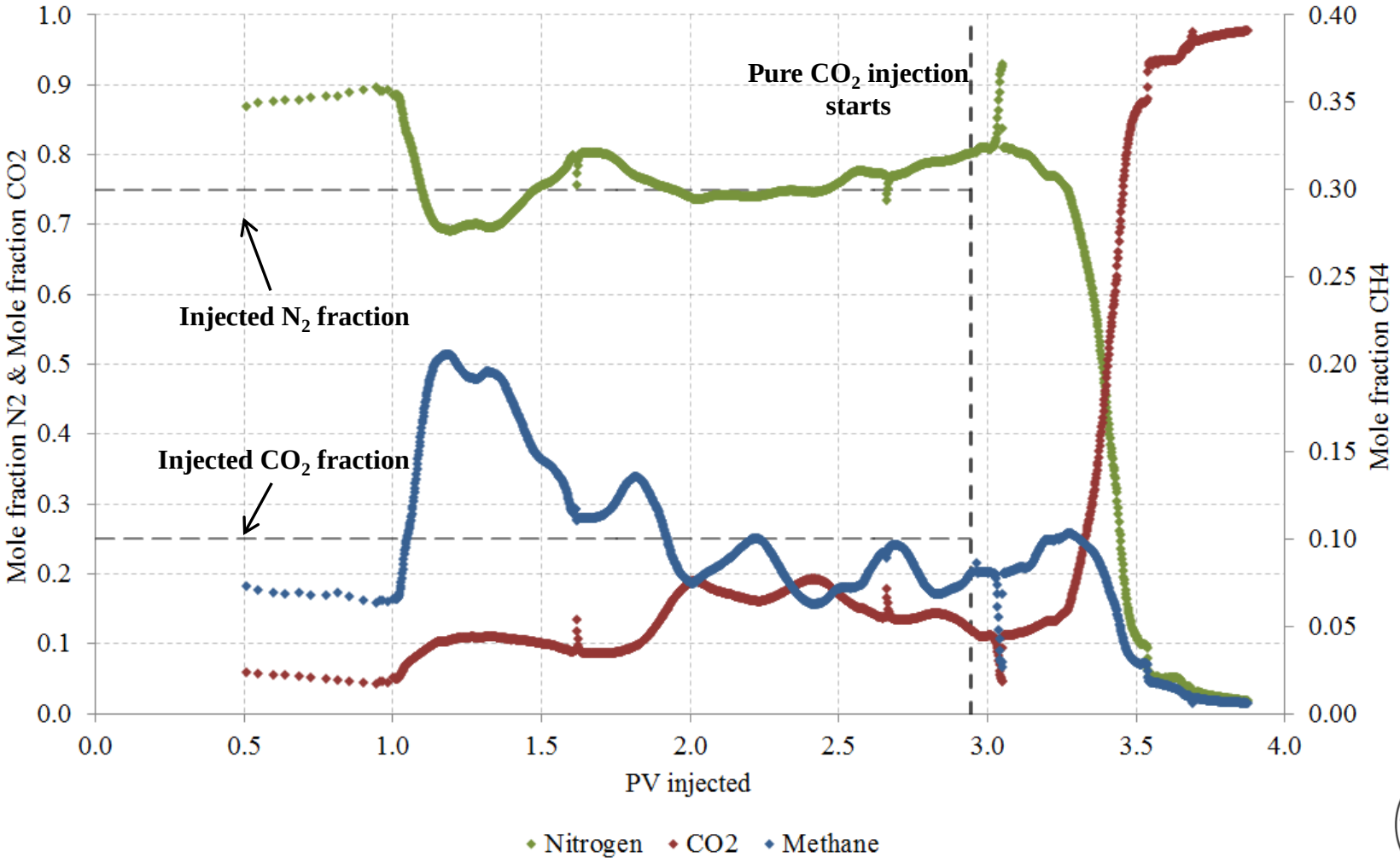
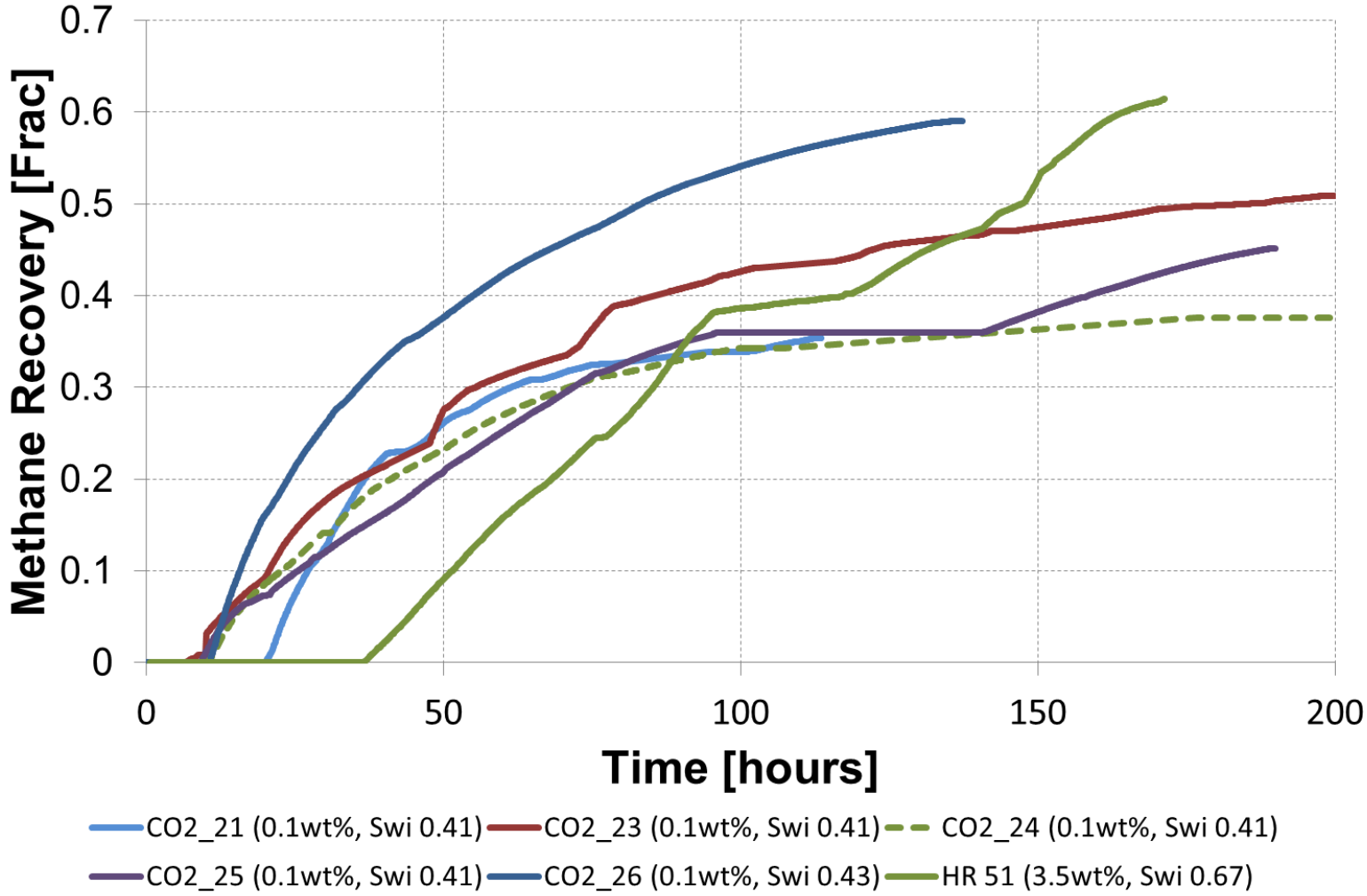


Methane recovery

Free gas in porous media included



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