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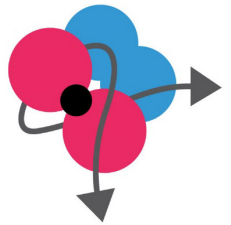

ELEGANCY

The influence of thermodynamic properties on CO_2 storage in saline aquifers

J P Martin Trusler and Geraldine Torín-Ollarves

ELEGANCY webinar 22 June 2020

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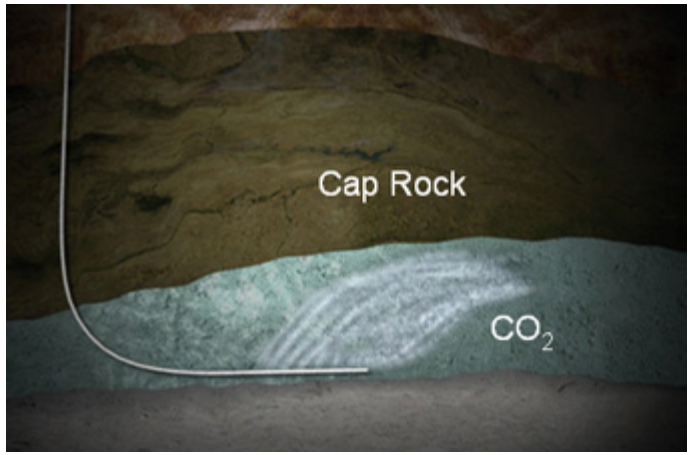
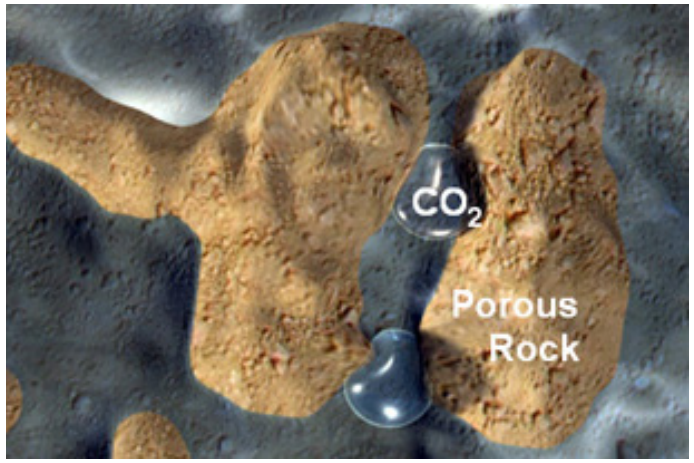
Geological Carbon Storage Mechanisms

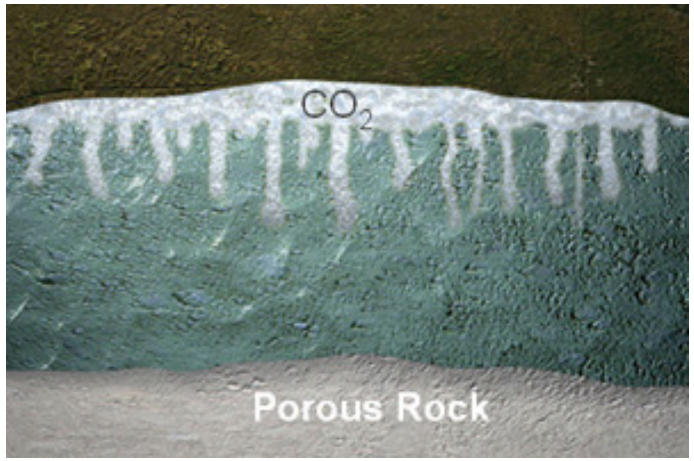
Structural trapping:



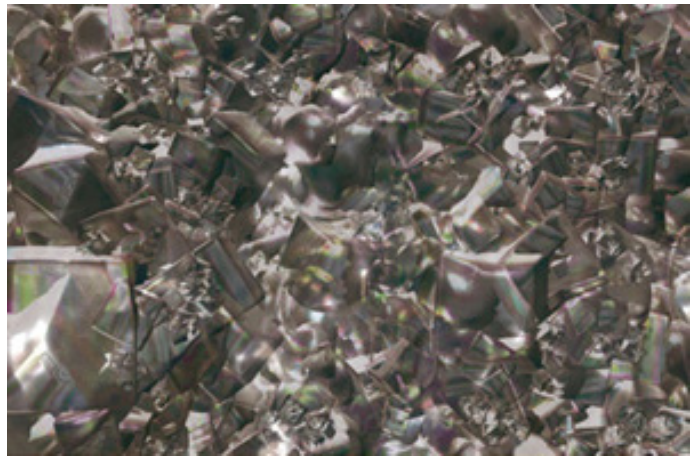
Residual trapping:



Solubility trapping:



Mineral trapping:



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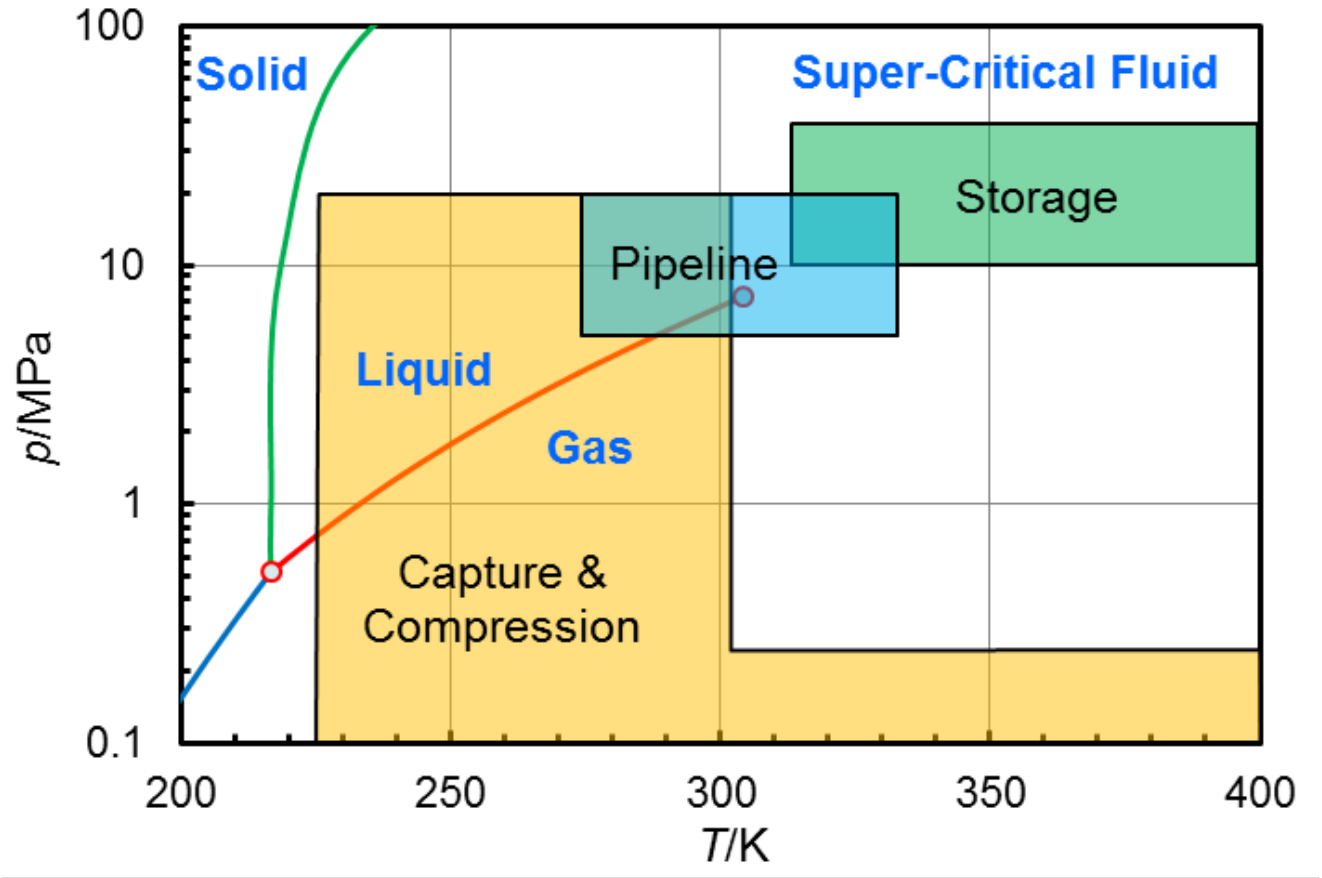
Thermodynamic State and Composition



Components slate:

- Carbon dioxide
- Diluents:
  N_2, O_2, CO, Ar, H_2
- Acid Gases:
  H_2S, COS, SO_2
- Aqueous species:
  H_2O, amines, salts
- Hydrocarbons:
  Gas, condensates, oils
- Others:
  NO_x, trace elements

Hydrogen + CCS: CO_2 for storage will contain H_2 impurity

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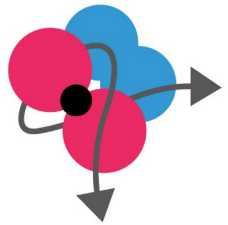

Role of Thermophysical Properties in CO_2 Storage

Process	**Properties**	**Controlling**
Structural & residual trapping	Interfacial tension Contact angle	Capillary pressure
Solubility trapping	Mutual solubility Diffusion coefficients Density, viscosity	Driving force Mass transfer rate Convective flow
Mineral trapping	*p*H	Mineral dissolution rate

Focus in ELEGANCY: effects of H_2 impurity on properties

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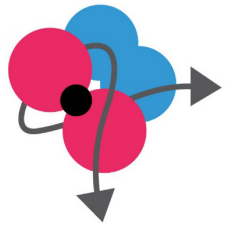
Objectives of ELEGANCY for CO_2-Brine-Impurity Properties



- Develop advanced models for the thermodynamic properties of systems containing CO_2, brines and impurity gases (especially H_2)
  - Model development requires experimental data, on (pseudo) binary mixtures, e.g. CO_2 + brine, H_2 + brine
  - Lack of solubility data for H_2 in brines at storage-reservoir conditions
- Measure the solubility of H_2 in water and brine

Model development: RUB

Experimental solubility measurements: ICL

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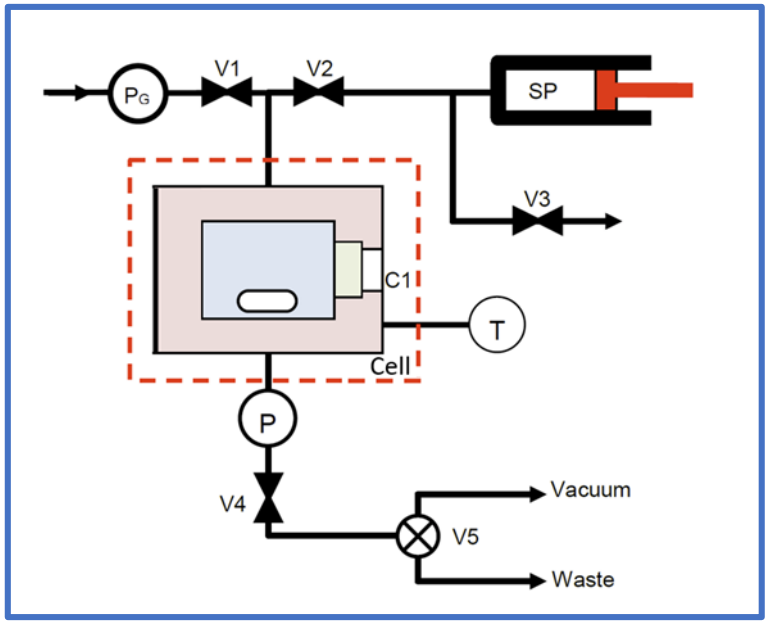
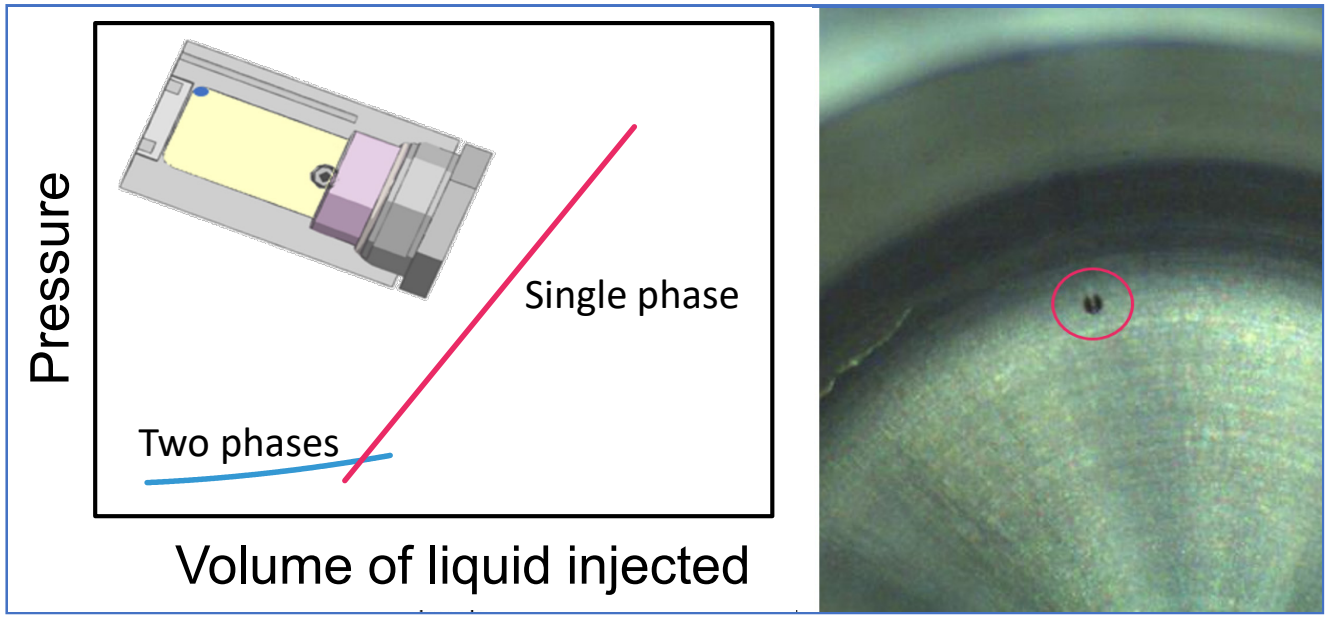
Bespoke experimental apparatus





- Operation conditions: pressures ≤ 70 MPa and temperatures ≤ 473.15 K
- Fill gas → inject liquid → Disappearance of bubble → PV analysis

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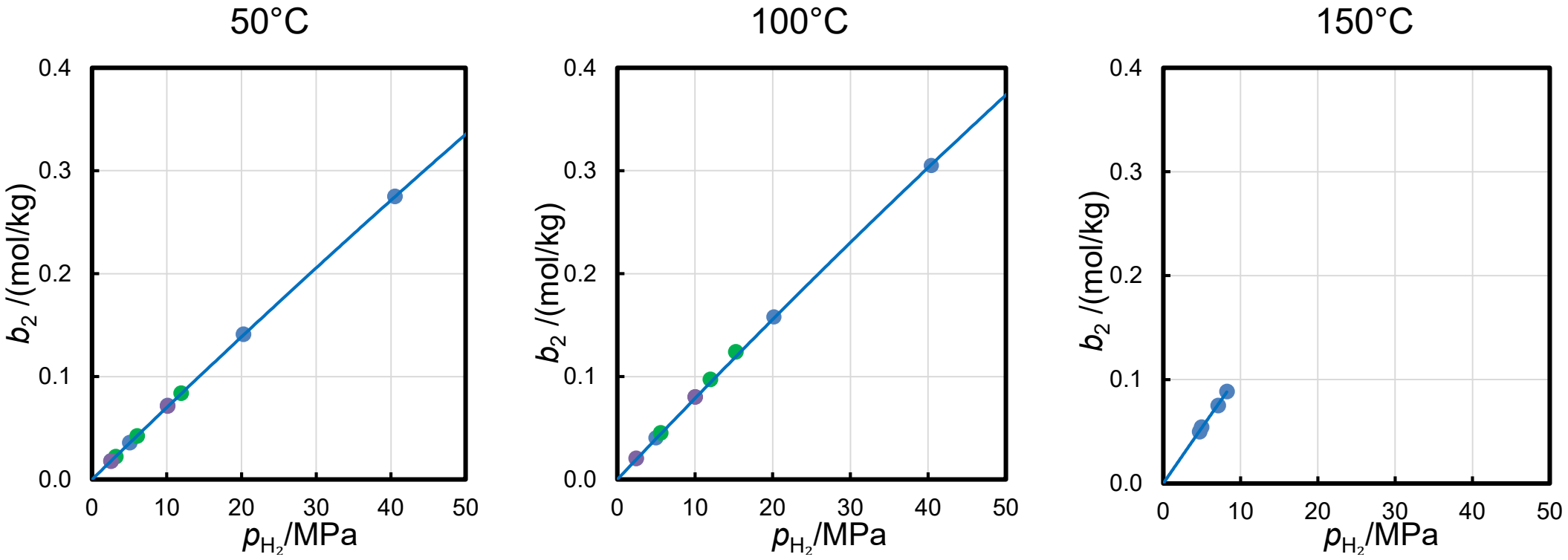
Available Literature data: H_2 solubility in H_2O



Solubility expressed in units of moles of H_2 per kg of water

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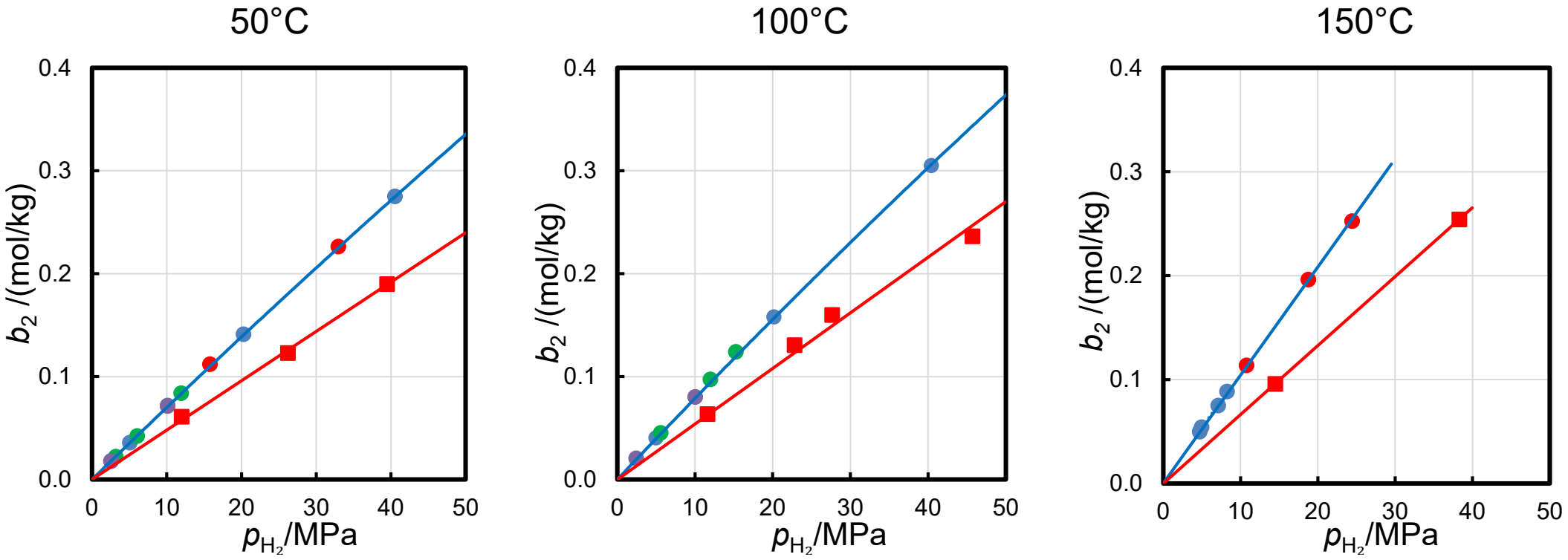
Add new data: H_2 solubility in H_2O and NaCl brine

●, new data H_2 on water; ■, new data H_2 in 2.5 mol/kg NaCl brine



Solubility expressed in units of moles of H_2 per kg of water

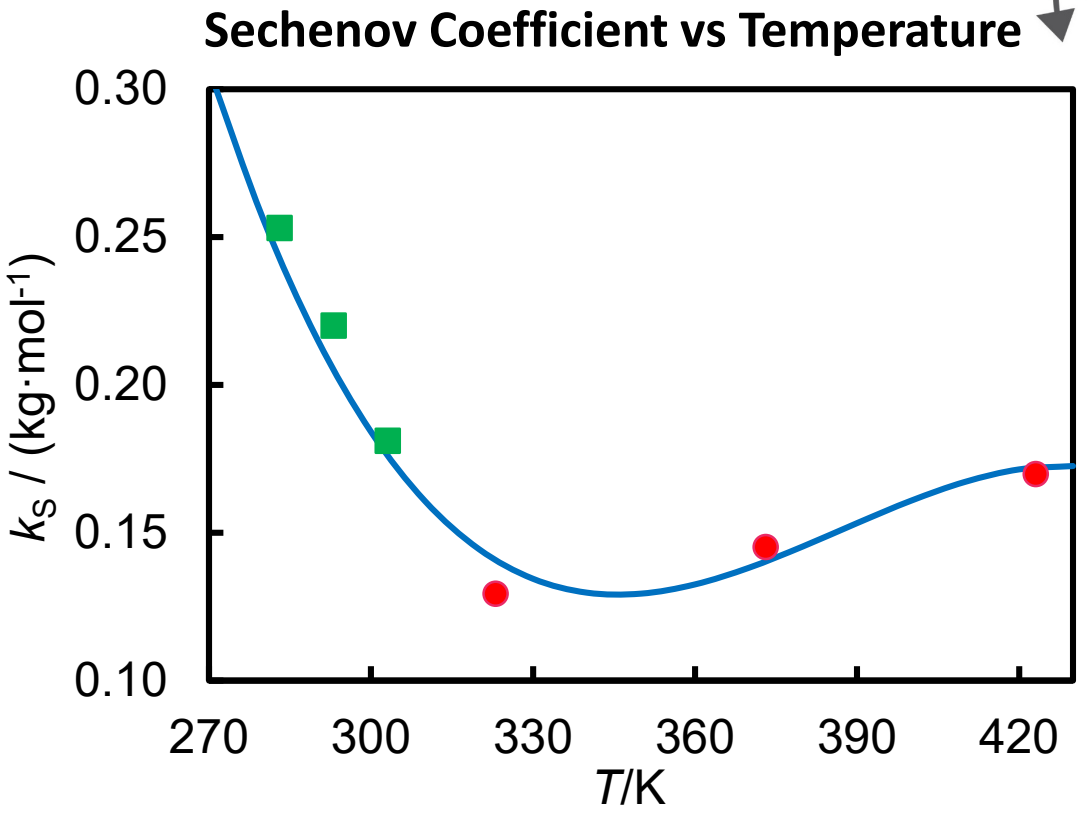
Salting-Out Effect

For sparingly-soluble gases like H_2:

$$\ln\left(\frac{\text{solubility in brine}}{\text{solubility in water}}\right) = -k_s b_s$$

b_s = molality of salt
(mole of salt per kg of water)

k_S = Sechenov coefficient
(function of temperature, independent of pressure)



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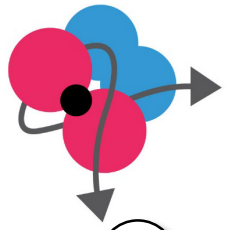

Start → Review literature → Design and Building → CO_2 / H_2O → H_2 / H_2O → H_2 / Brines

Summary and Conclusions:

- Available data for H_2 solubility in water extended to higher temperatures
- First measurements of salting-out effect for H_2 in brine at reservoir temperature
- Provides the necessary data for model development

Acknowledgement

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Accelerating CCS Technologies