Mixing behaviour of methanol stored in depleted hydrocarbon reservoirs to support the European Union energy transition

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Motivation

Quantify mixing behaviour of methanol with water in subsurface storage reservoirs

- Long-term storage of energy carriers is required for transition to renewable sources scheduled in the EU [1]
- Power-to-Methanol as additional option to Power-to-Gas to convert surplus energy into storable energy carriers and chemical feedstock
- Methanol requires lower operational and safety measures compared to natural gas (CH_4) or hydrogen
- Main concern besides biodegradability is methanol miscibility with water, potentially resulting in storage losses in depleted hydrocarbon reservoirs
- Present study aims at quantitative assessment of mixing behaviour of methanol and water based on a reference numerical simulation benchmark

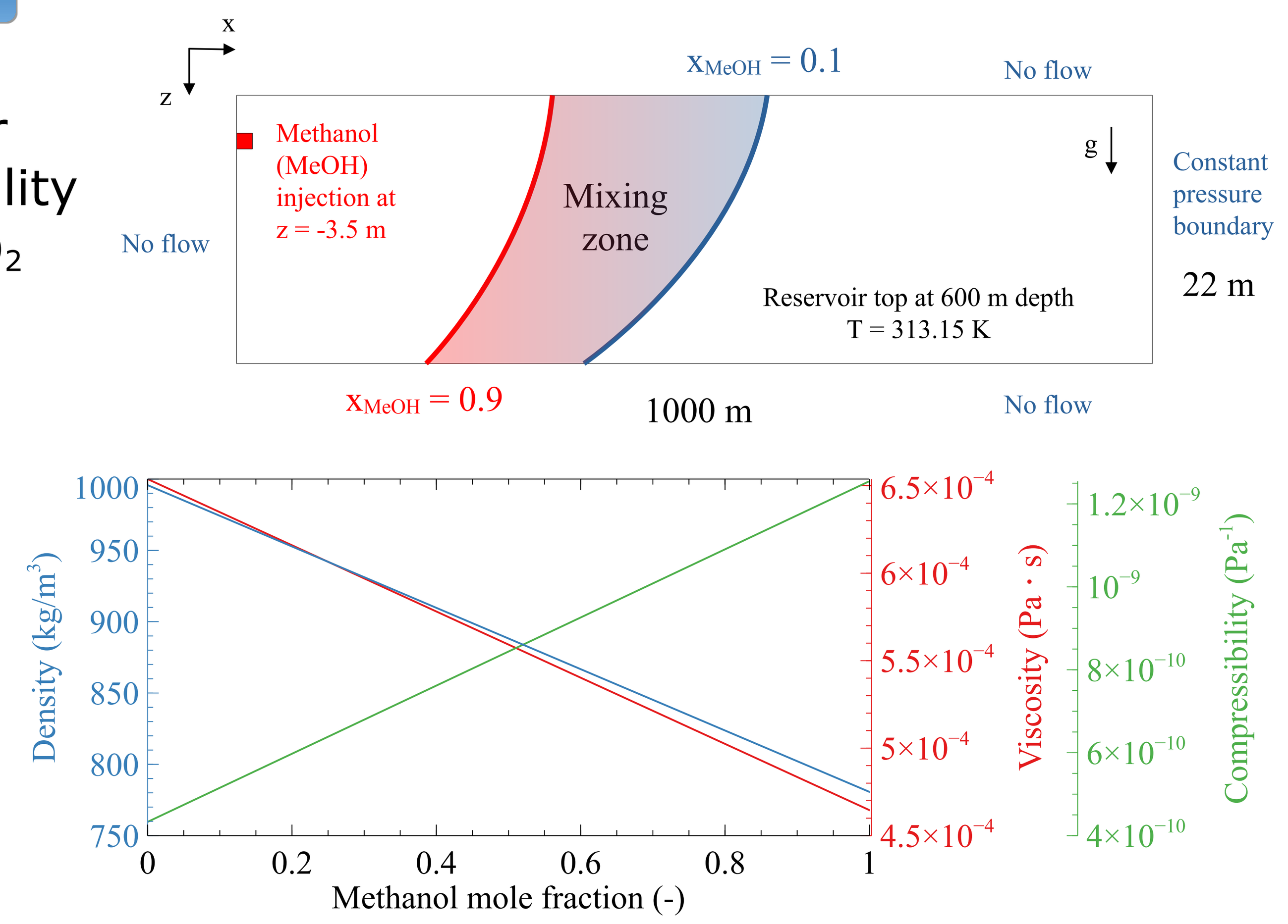
Methods

Application of reference benchmark applied in natural gas storage to access mixing degree

- TRANSPORTSE [2,3] with equations of state for methanol-water mixtures [4] applied to consider variations in fluid density, viscosity and compressibility
- Reference benchmark for CH_4 storage [5,6] with CO_2 cushion gas adapted for low fluid compressibility
- Mixing degree [6] quantifies storage losses (η) based on mixing zone (V_{mix}) and reservoir volumes (V):

$$\eta = \frac{V_{mix}}{V}$$

- Storage loss quantification depending on:
  - Syncline and anticline systems (±10° dip angle)
  - Variations in storage formation thickness (22, 50 and 100 m)
  - Hydrodynamic dispersion



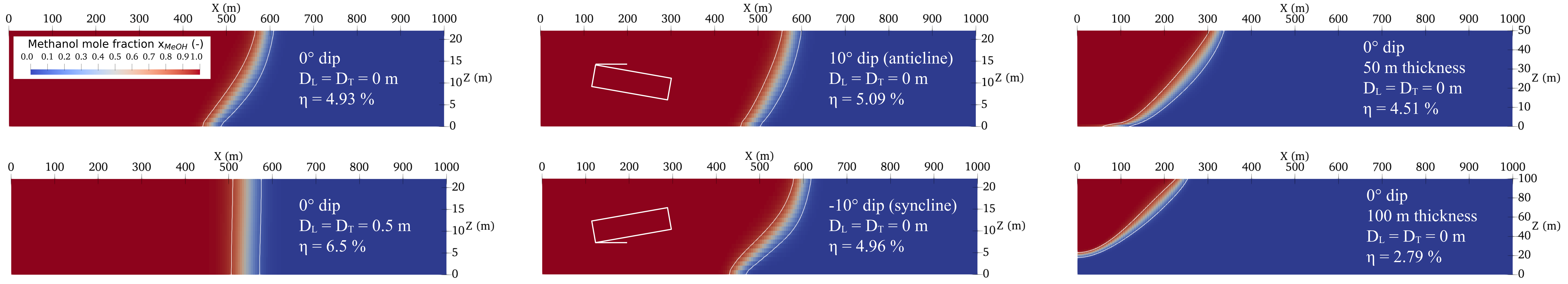
Conclusions

High storage efficiencies compared to natural gas with alternative cushion gases

- Relatively low mixing degrees (5.1 % in maximum) compared to CH_4 storage with CO_2 cushion gas (up to 18.5 %, [6]) due to lower density, viscosity and compressibility variations
- Variations in p/T conditions are negligible for methanol storage in hydrocarbon reservoirs
- Diffusion coefficient not relevant at investigated time scales
- Mixing degree decreases with increasing storage reservoir thickness, while impact of reservoir dip is negligible
- Further research requirements related to storage efficiency:
  - Cyclic methanol storage with injection and production
  - Anaerobic methanol biodegradability
  - Structural geologic and permeability heterogeneities

Results

Relatively low mixing degrees after reference simulation time of 180 days



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