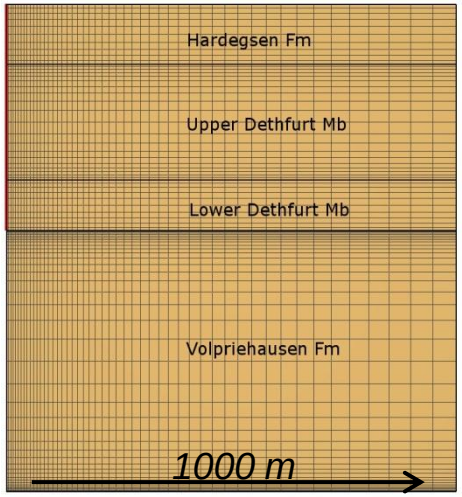
Problem description

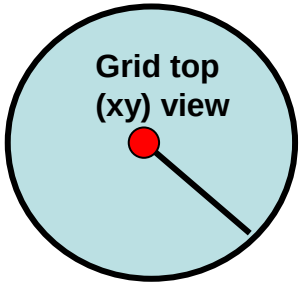
Define equilibrium water and gas saturation in gas reservoirs

Model gas reservoir



Known reservoir properties

- Porosity and permeability (per layer)
- Capillary pressure (P_{cap}) (per layer)
- Free water level (FWL)
- Pressure and temperature



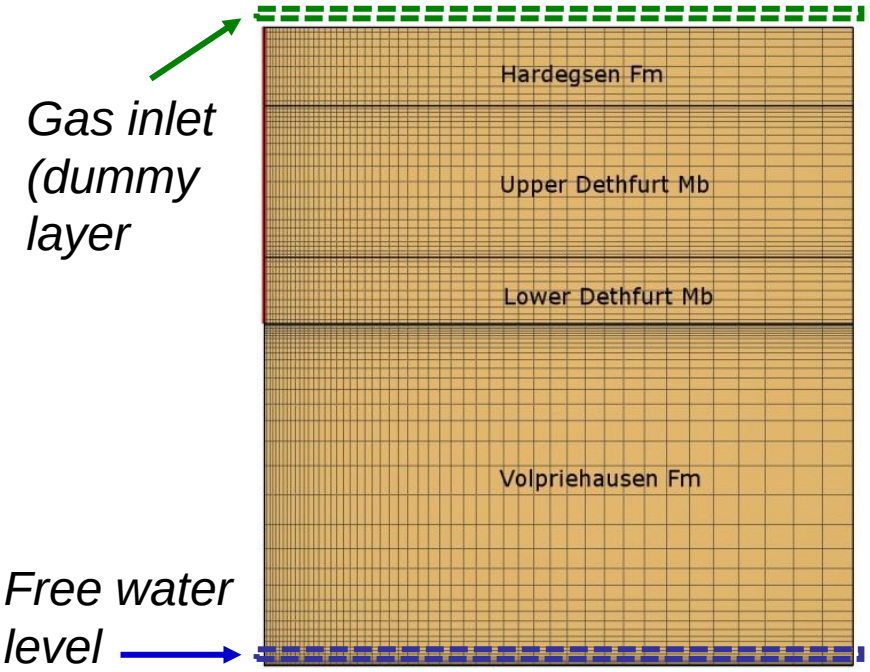
Unknown reservoir properties

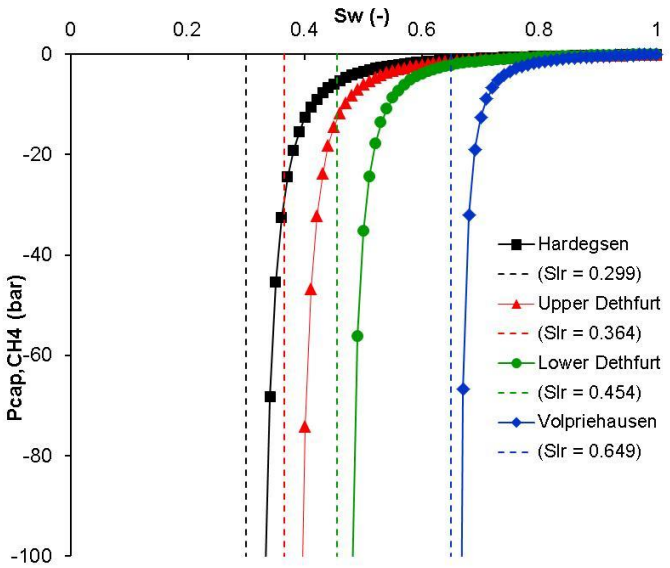
- Equilibrium gas saturation (S_g) and water saturation (S_w)

Compute equilibrium S_w - Why important?

- Equilibrium S_w depends on $P_{cap}(S_w)$ (and height above FWL)
- S_w < residual S_w → no flow
- S_w > residual S_w → flow

Gas reservoir with 4 layers





- Each layer has a different $P_{cap}(S_w)$
- FWL located in lowest layer of grid blocks
- Add gas inlet (dummy layer) on top of the reservoir
  - Very thin (e.g. 1 cm)
  - Turn off capillary pressure!

Three step approach

Step 1: Compute pressure profile over depth

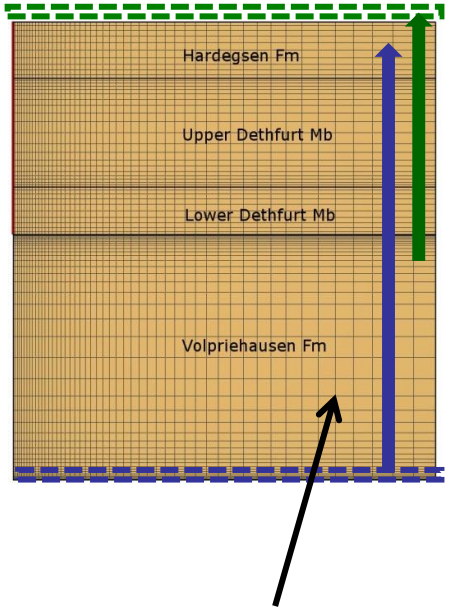
- Fill reservoir with gas (S_g=1), no water (S_w=0)
- Define <P> and compute P over depth

Step 2: Compute S_w and S_g

- Read in pressure data from step 1 (use SAVE file)
- Assign FWL → S_w=1 and inactive (constant P)
- Gas inlet → keep S_g=1 and inactive (constant P)
- Other cells → keep S_g=1 (S_w=0)
- Run the simulation

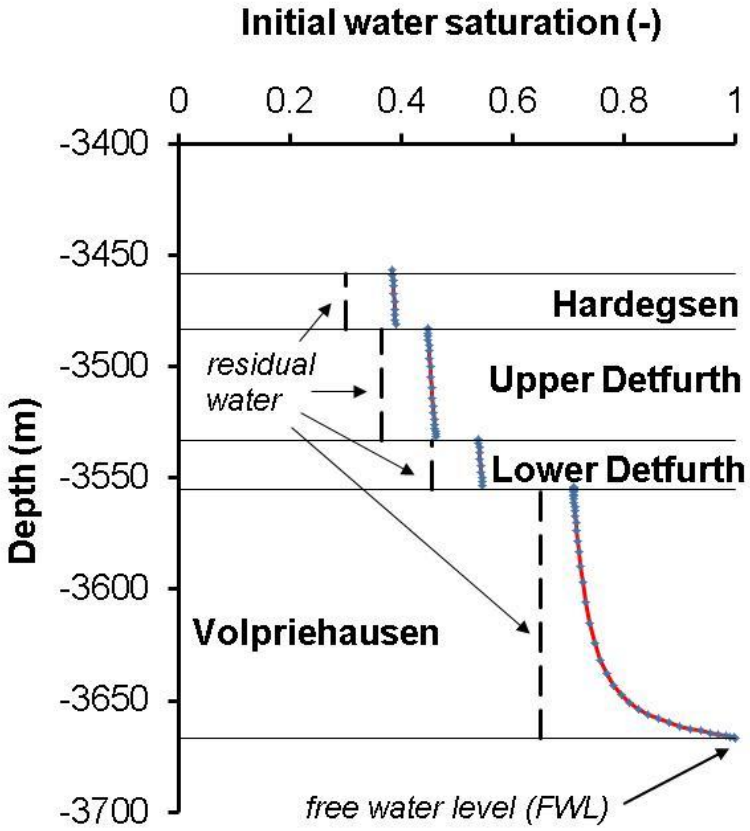
Step 3: Equilibrium check

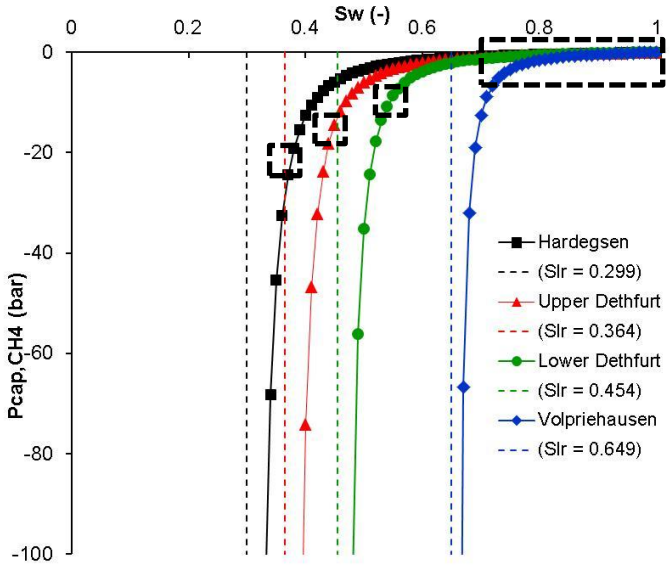
- Remove dummy layer and check



- Water flows in from FWL
- Gas flows out to gas inlet
- Final pressure similar to pressure from step 1

Result: equilibrium S_w





Effect of Gas Field Production And CO_2 Injection on Brine Flow and Salt Precipitation

Paper TOUGH Symposium 2012

Imbibition and drainage

Drainage (S_w=1)
- Water flows out to FWL
- Gas flows in from gas inlet

Imbibition (S_w=0)
- Water flows in from FWL
- Gas flows out to gas inlet

Depends on geological history?

Both approaches give a similar results without hysteresis