

A decorative graphic on the left side of the slide consists of a grid of dots. The dots are arranged in a roughly rectangular shape, with some dots missing to form a frame. The dots are in various shades of purple and blue. The text 'sck cen' is centered within this grid.

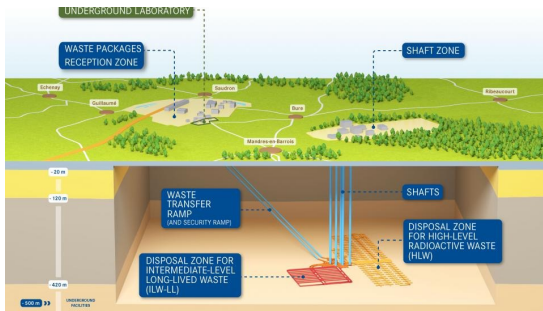
sck cen

Belgian Nuclear Research Centre

Measuring diffusion of gas in partly saturated clay

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Gowrishankar - 22/11/2023

A bit of background

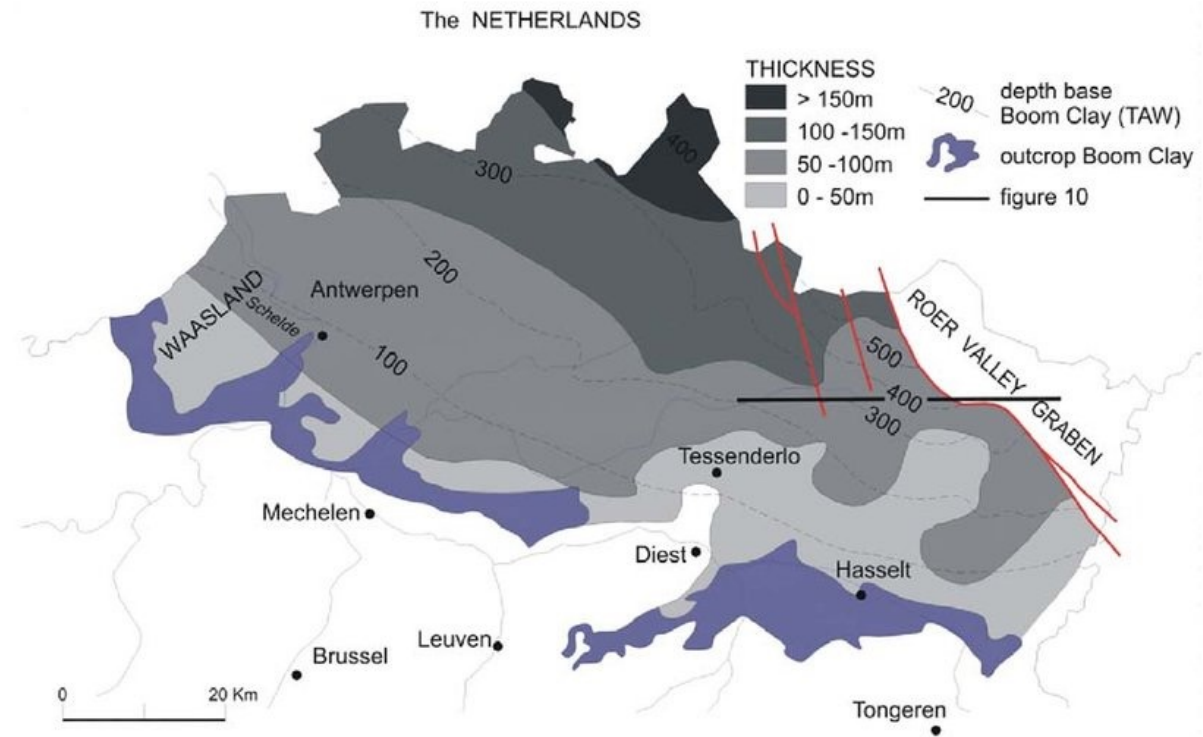


A bit of background

- Disposal in clay
- Why clay?
- Low hydraulic conductivity
- High sorption capacity
- Self sealing



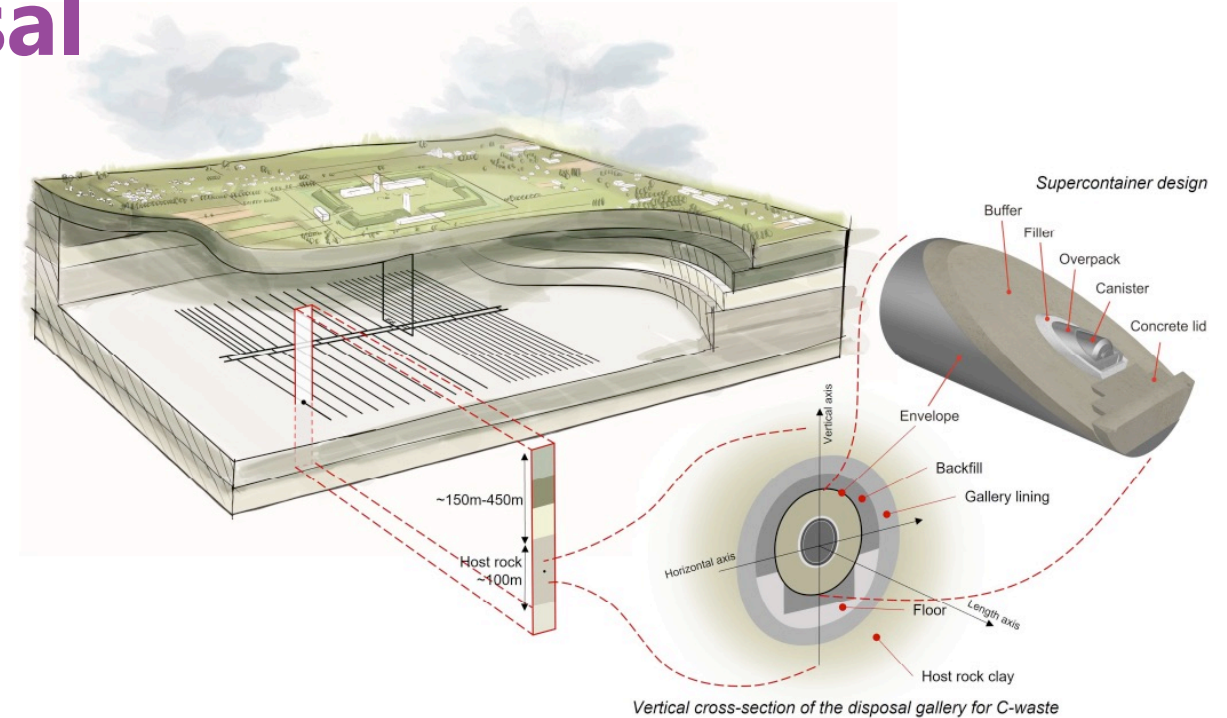
- Reduced mobility of radionuclides



Potential host rock in Belgium: Boom Clay

Gas in geological disposal

- Considerable amounts of gas can be produced in a repository
 - Mostly hydrogen (anaerobic corrosion of steel and reactive metals)
 - Degradation of organics wastes & radiolysis also produce gas

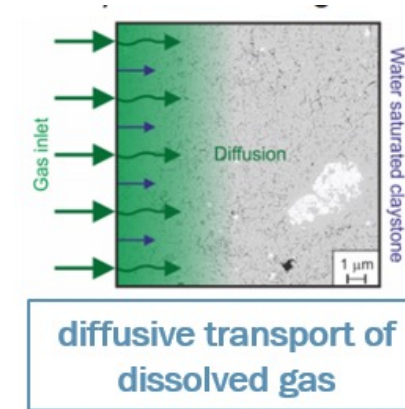


→ **Significant volumes: several times the excavated volume but generated over a long time period**

→ **Different evacuation pathways**

Gas transport modes in clays

- Transport of solutes → mainly diffusion
 - Characterized by diffusion coefficients
- Need for diffusion coefficients:
 - Radionuclides
 - Many data available
 - Dissolved gases (gas generation in repository)
 - Noble gases, light hydrocarbons, hydrogen



$$J = -D \frac{dC}{dx}$$

D is diffusion coefficient

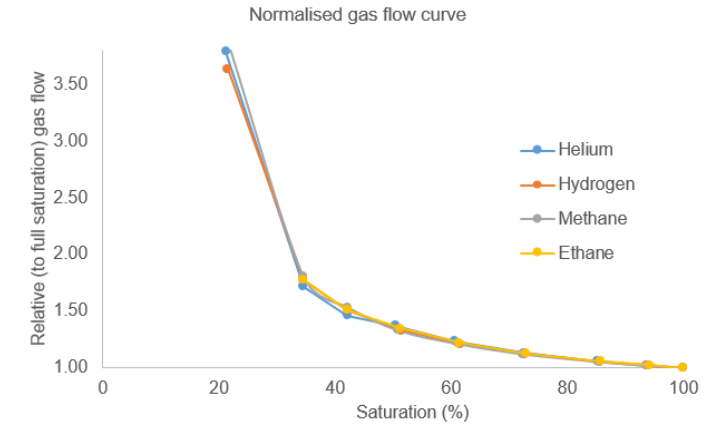
C is concentration

x is distance

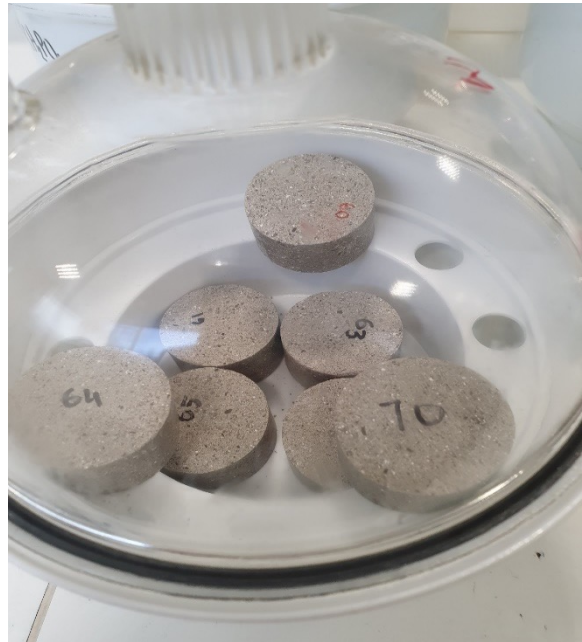
J is flux

Open questions

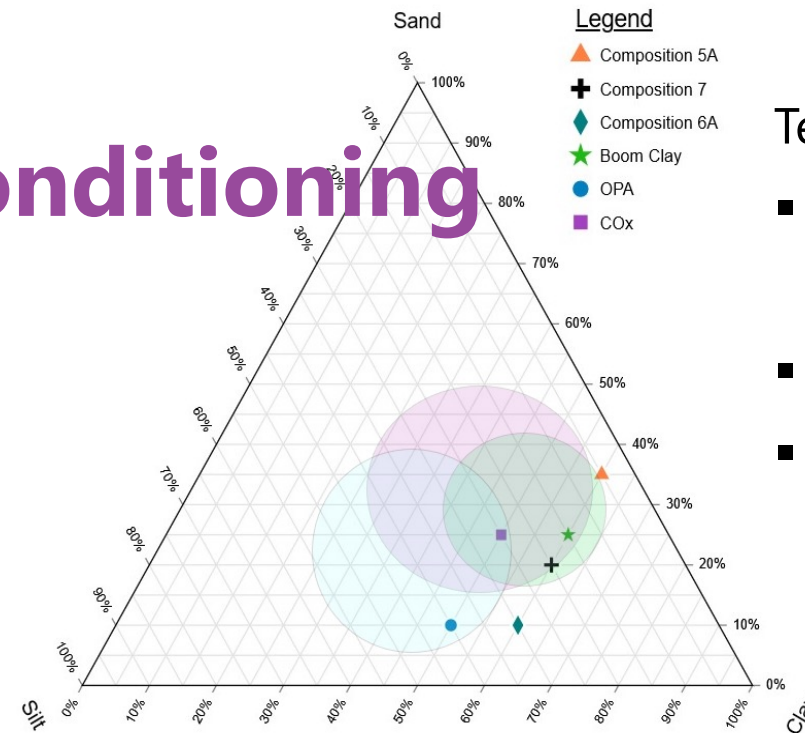
- What we have?
 - Large data set of diffusion coefficients
 - Different gases (noble gases, light hydrocarbons, H₂)
 - Different materials (Boom Clay, Sand of Eigenbilzen, Callovo-Oxfordian clay, Opalinus Clay, bentonite, shale, cement-based materials, geopolymers, ...)
 - But: all on saturated samples
- What is missing?
 - Unsaturated conditions might exist in host rock and engineered barriers
 - After repository closure or due to gas generation
 - What is impact of desaturation on gas diffusion coefficients?
 - Also need to understand process
 - Use "simple" systems with known mineral phases → easier to understand + transferability of results



Samples & conditioning

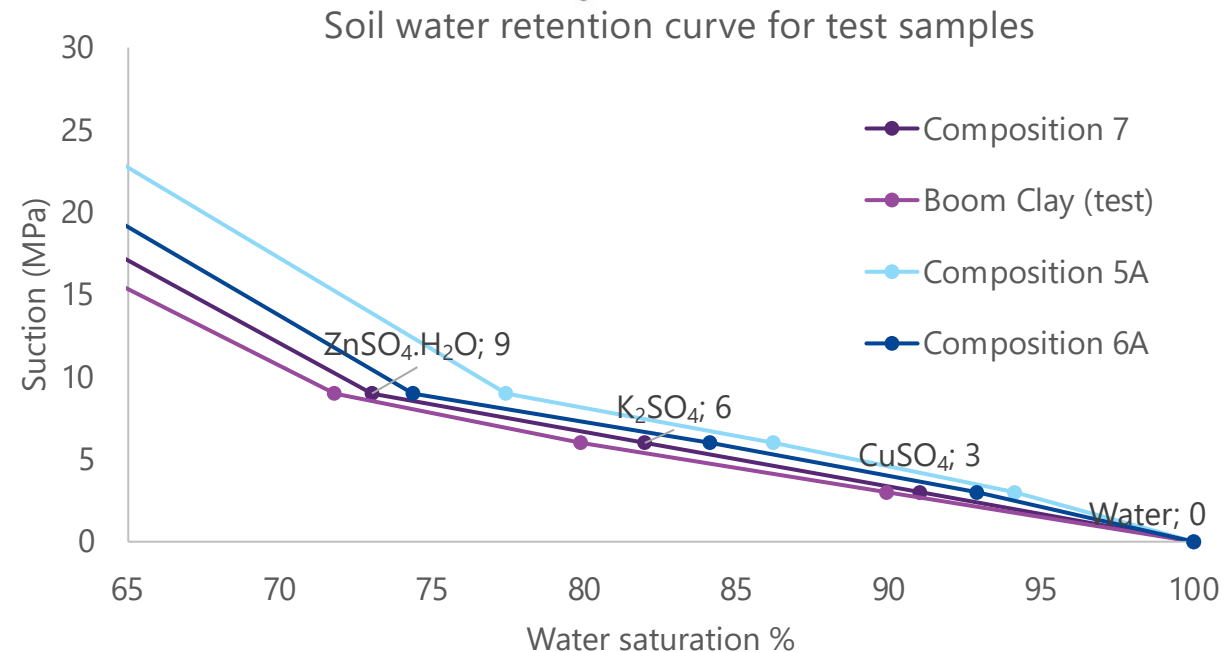


Synthetic clay sample conditioning – vapour equilibrium.

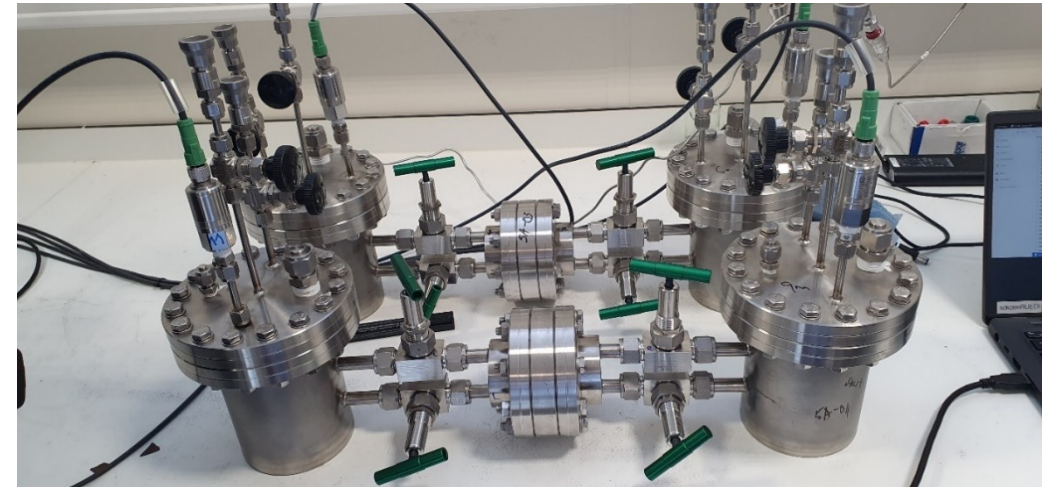
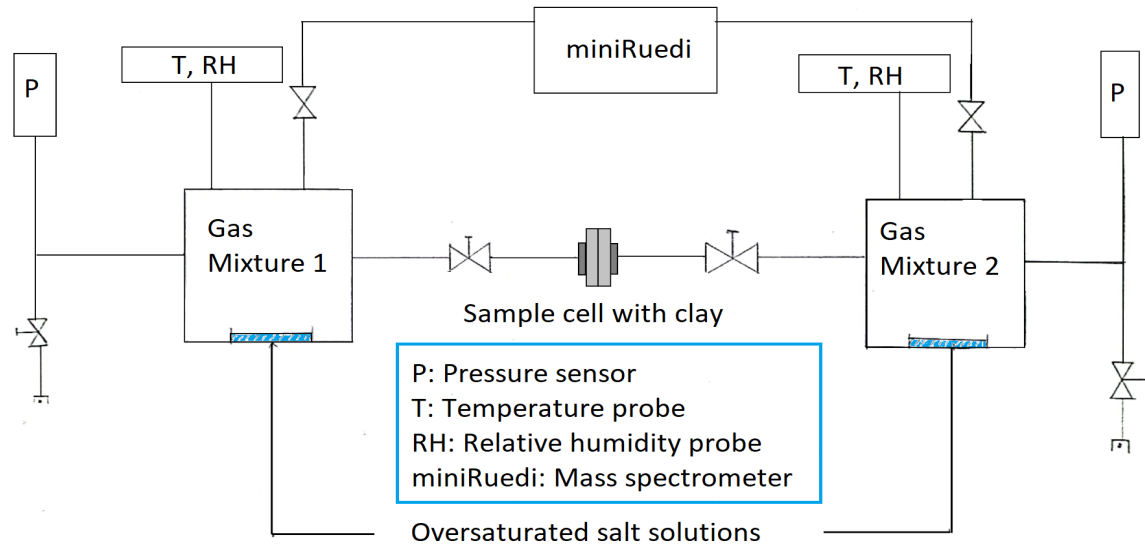


Ternary mixtures of sand, silt and clay.

- Clay : 80% MX80 and 20% kaolinite (63-125 μm)
- Sand: Pure quartz sand (63-125 μm)
- Silt: Pure muscovite mica (<63 μm).



Overview- Diffusion experiments

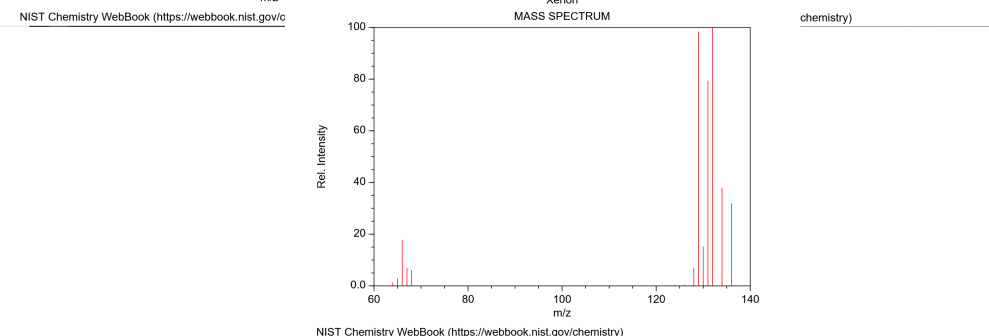
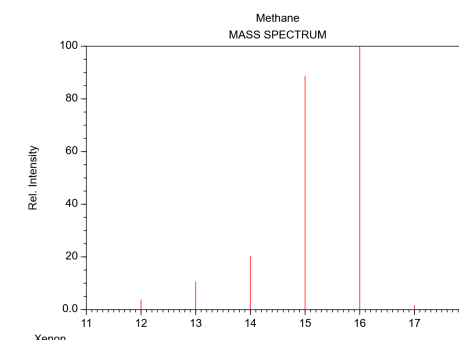
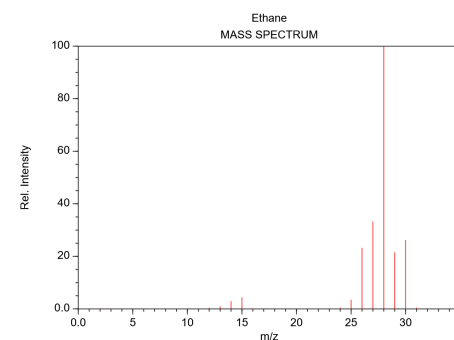


- Equal pressure in both vessels (around ambient) → diffusion only
- Room temperature
- Constant RH by using oversaturated salt solutions
- Measure gas concentration increase as function of time

Gas analysis

- First idea: cross diffusion of 2x 2 gases
 - He and CH₄
 - Xe and C₂H₆
 - → too much peak overlap
- Simplified idea:
 - He
 - Ar
 - → no more overlap (but less data per test)

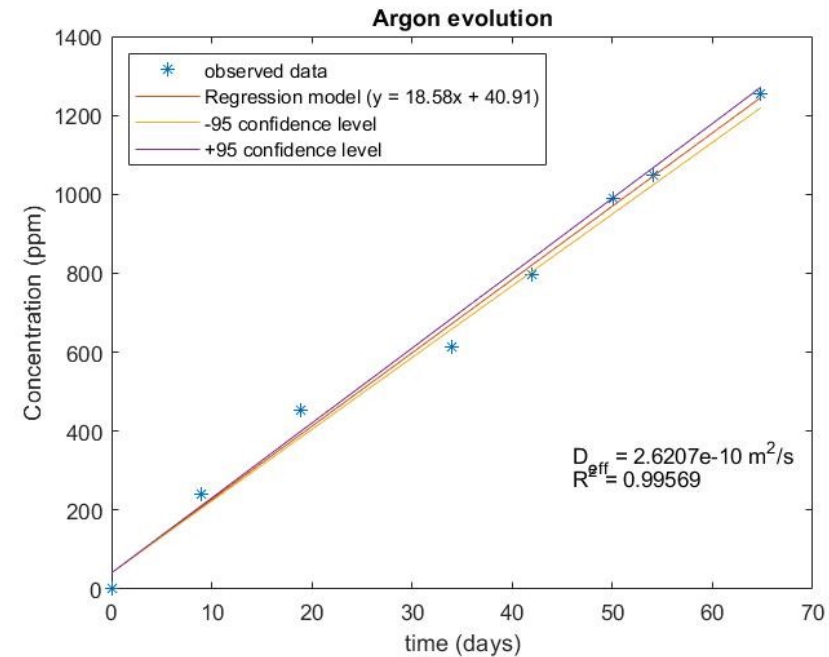
	m/z	Detector
He	4	F
CH ₄	15	F
Xe	129	F
C ₂ H ₆	30	F
Ar	40	F



Gas analysis

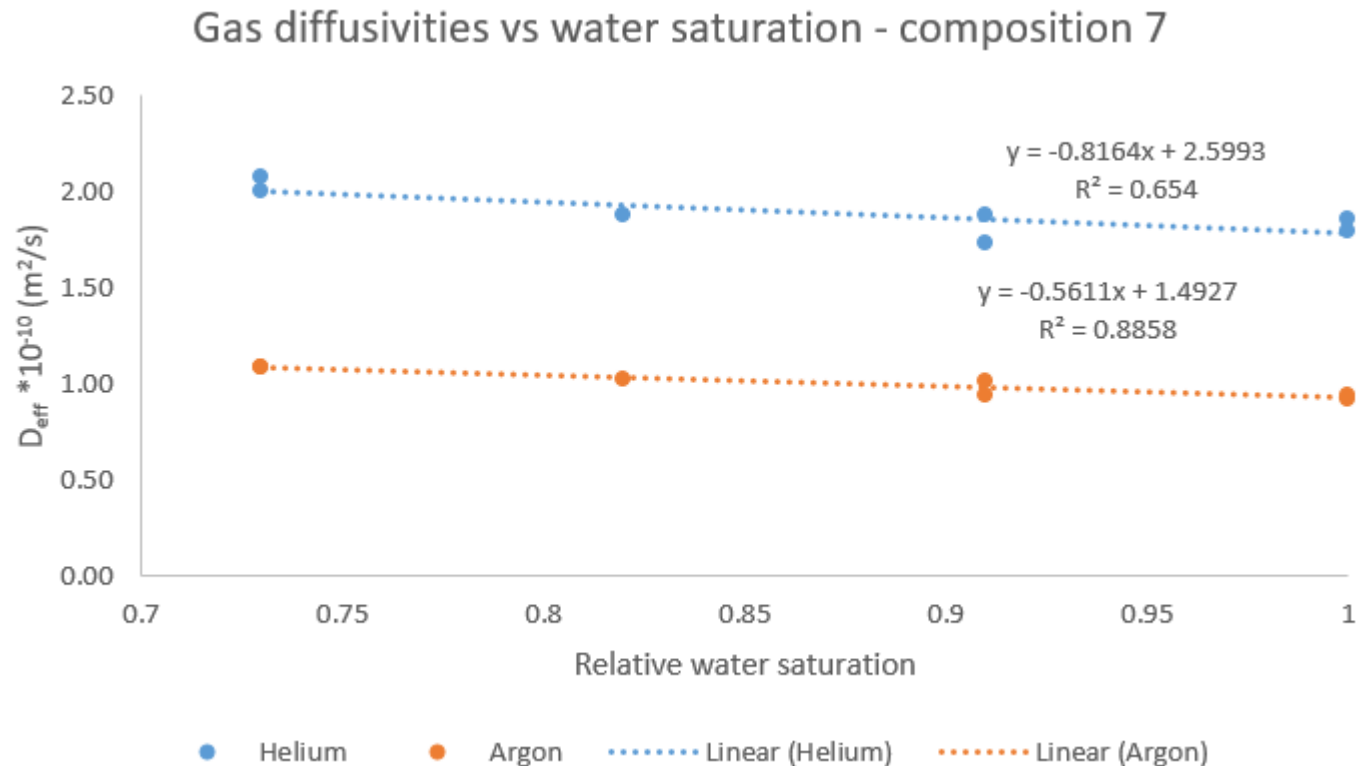
- Effective diffusivity- analytical solution of Fick's first law

$$N_A = \left[\frac{D_{AB} P_t}{RTZ} \right] \ln \left[\frac{1 - y_{A2}}{1 - y_{A1}} \right]$$



Results

- Series of diffusion coefficients for synthetic samples



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