μ-CT Study of CO_2-Gas Exsolution caused by Rough Surfaces

Bilal Zulfiqar[1], Steffen Schlüter[1], Helmut Geistlinger[1]

[1]: Helmholtz Centre for Environmental Research -- UFZ, Department of Soil System Science, Leipzig, Germany

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Objectives

- Injection of **CO_2-Super-Saturated water** and subsequent Gas Exsolution ⟹ Important applications [CCS, residual NAPL-remediation, CO_2-enhanced oil recovery]
- New Gas Exsolution Phenomena of **CO_2-Equilibrated-water** in Porous Meadia with ROUGH SURFACES
- **μ-CT-Column Experiments** to study Gas Exsolution and **Gas Cluster Formation/Distribution** in 3D-porous media (natural sand, glass beads, fine sand)
- **New Result: CO_2-saturated water** injection, already leads to Gas Exsolution of significant amount
- **Heterogeneous Fluid-Rock Interactions**, e.g. Hydrophobic nucleation sites and heterogeneous wettability has a dramatic impact on **Capillary Trapping Efficiency**
- **RESULTS: Residual Gas saturation in Glass beads (1mm): 12-18%, Natural sand (1mm): 16 - 23%, Fine sand (0.17 mm):**
- Key-parameter for **GAS-cluster-dissolution**: GAS-water-Interface **A_{gw} (see Fig.5 and Table 1)**
- Gas-water interface **A_{gw} is about 60%** of the total gas surface **A_g**

Methods

- **pH electrode** to control CO_2-concentration
- Gas-saturated water injection; **hydraulic potential method** (pre-defined **Δh**)
- Fluid-saturation measured; a) **gravimetrically** b) **μ-CT**

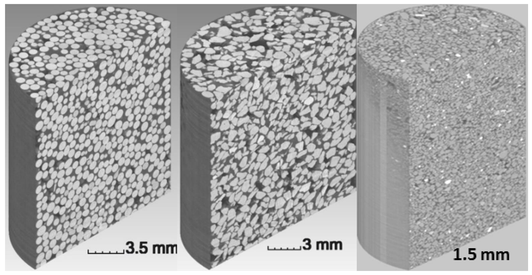


Fig 1. Raw CT images for 1mm-Natural sand , 1mm-GBS and fine sand

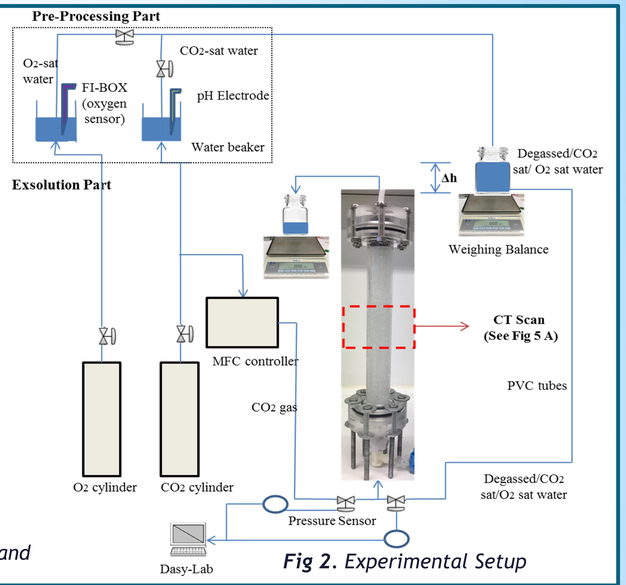
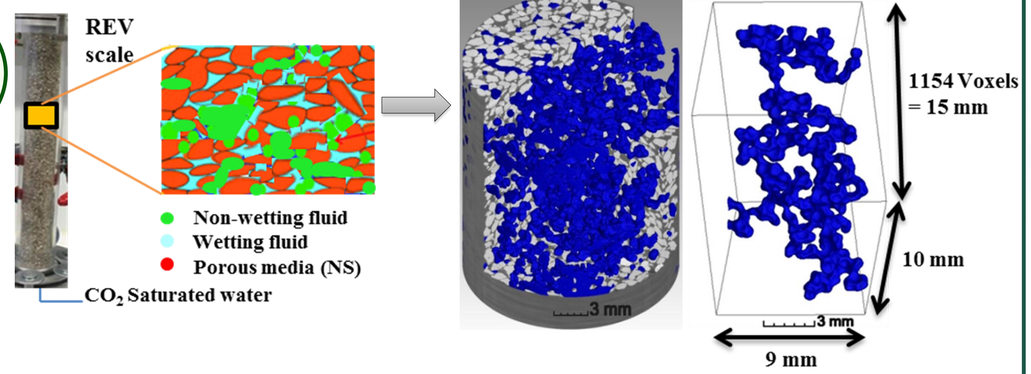


Fig 2. Experimental Setup

Results & Discussions: Gas Exsolution

Rough Surfaces (1mm-sand)

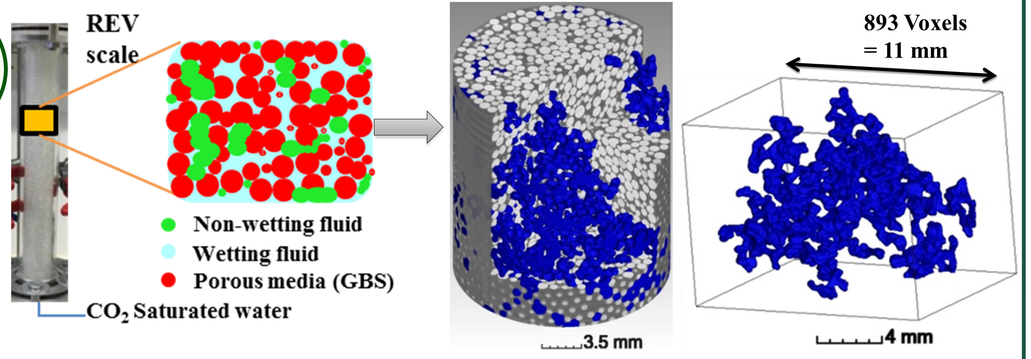
Why?



- *Rough surfaces exhibit gas-filled cavities and gas bubbles of different sizes which can be formed under certain **thermodynamic conditions (see Fig.3)***

Smooth Surfaces (1mm-GBS)

Why?



- *Chemisorbed molecules* **(see Fig. 4)**

Surface charge — Adsorbed dipole moment — Wetting behavior

Exsolution Process

A) Rough Surface

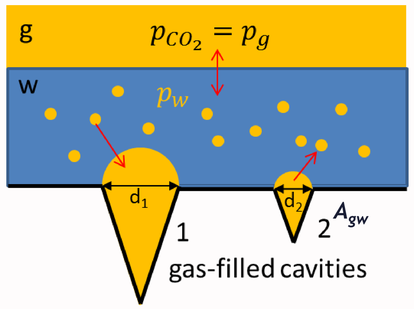


Fig 3. Bubble formation at two gas filled cavities of different size d_1 and d_2

B) Smooth Surface

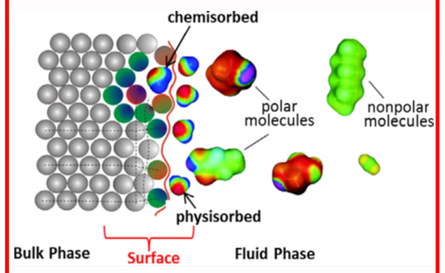
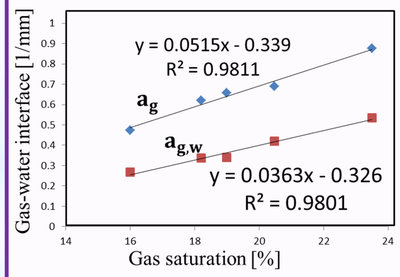


Fig 4. Real solid surface with faults and physisorbed & chemisorbed polar molecules present in the fluid phase

Hydrophobic nucleation sites ??

Quantification of the Gas-Water Interface

A) 1mm-Sand



Exp	Porosity [-]	Gas Content [-]	A_g (mm^2)	$A_{g,w}$ (mm^2)
1	0.377	0.160	2765	1568
2	0.380	0.182	3597	1957
3	0.392	0.190	3877	2008
4	0.390	0.205	4140	2530
5	0.385	0.235	5208	3185

B) GBS

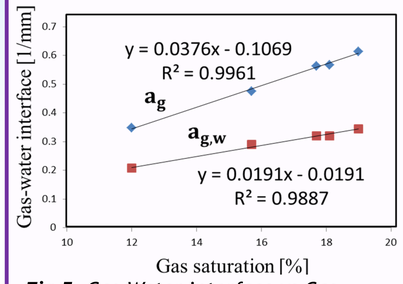


Fig 5. Gas-Water interface vs Gas saturation.

Exp	Porosity [-]	Gas Content [-]	A_g (mm^2)	$A_{g,w}$ (mm^2)
1	0.373	0.120	2078	1238
2	0.370	0.157	2886	1757
3	0.371	0.177	3376	1925
4	0.387	0.181	3405	1922
5	0.374	0.190	3584	2015

Table 1 Gas saturation & Gas-water interface.

References

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www.testum-aquifer.de

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Contact: bilal.zulfiqar@ufz.de