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Electrical monitoring of dynamic drainage and imbibition cycles in different rock-fluid-gas systems

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MOTIVATION

Understanding physico-chemical interactions and quantification of reaction kinetics during dynamic processes in multi phase systems and there impact on the electric conductivity can help to interpretation EM-monitoring data.

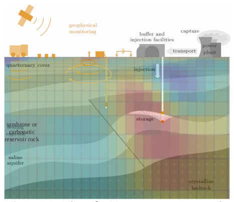

Fig.1 Principle of CO_2 sequestration and geophysical monitoring methods

Within the experimental laboratory work changes of electrical properties of different rock-fluid-gas systems during dynamic processes were monitored. The rock-fluid-gas systems were selected after there increasing potential in electro-chemical interactions.

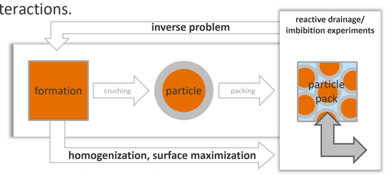

Fig.2 project work concept

DATA PROCESSING

data Input 8288 spectra → **temperature correction** $\sigma^*(T_2) = \sigma^*(T_1) \cdot \frac{T_2 + 21.5}{T_1 + 21.5}$ → **normalizations** $|Re(\sigma^*)|, |Im(\sigma^*)|$, $|\varphi(\sigma^*)|, |t_{event}|, |S|$ / **calculations** (e.g. saturation) → **visualizations**

MATERIAL UND METHODES

AUTOCLAVE

- pressure up to 30 MPa and temperature from 8 – 80°C
- imbibition with HPLC-Pump

SIP-FUCHS III *from Radic Research*

- pressure cell is equiped with platine-mesh-electrodes for current injection and platine-ring-electrodes for potential measurements

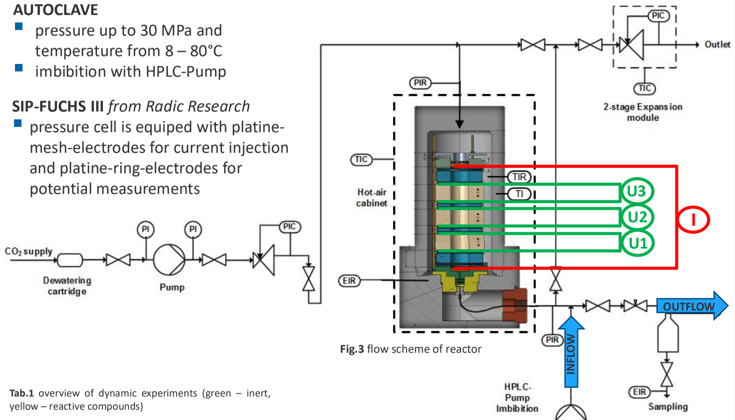

Fig.3 flow scheme of reactor

Tab.1 overview of dynamic experiments (green – inert, yellow – reactive compounds)

ID	SIP-Date	Fluid	Gas
1	sand	carbonate water	N_2
2a - 2c	sand	carbonate water	CO_2
3	crushed carbonate	carbonate water	N_2
4	crushed carbonate	carbonate water	CO_2

MONITORED PARAMETERS

- height-oriented SIP-measurements
- mass and electric conductivity of effluent
- pressure & temperature in autoclave

EXPERIMENTAL CONDITIONS

- temperature 15 °C
- pressure until equilibrium 2 MPa
- full saturation condition at starting point
- static conditions f > 5 mHz & dynamic conditions f > 90 mHz
- 3 x drainage & 2 x imbibition processes
- pressure steps & duration at drainage processes (46 min @ 0.2 MPa, 31 min @ 1 MPa, 15 min @ 2 MPa)
- flow rate at imbibition processes with Q = 1ml/min

RESULTS

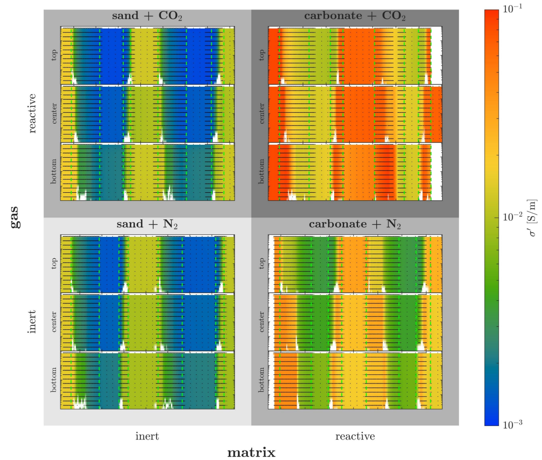

Fig. 4 real part of complex conductivity (colors) plotted vs. frequency (y-axis) and time (x-axis) for two subsequent drainage and imbibition cycles

- real part of the el. conductivity decreases by about -90% in the dewatered states
- after imbibition the el. conductivity increases differently depending on material and measuring height
- combination of reactive materials show the strongest conductivity changes after dynamic processes

OUTLOOK

- evaluation of imaginary part of complex conductivity
- repeating dynamic experiments under reservoir condition (T = 70°C & p = 25 MPa)
- comparing results with reactive flow modelling

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Referenzen:
Börner et. al., [2017]: Spectral induced polarization of the three-phase system CO2 - brine - sand under reservoir conditions
Börner et. al., [2015]: The electrical conductivity of CO2-bearing pore waters at elevated pressure and temperature a laboratory study.
Waxman, M., Smits, L. [1968]: Electrical conductivities in oil bearing shaly sands, Society of Petroleum Engineers Journal, Vol. 8

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