

EGU24-11251, updated on 15 Jul 2024

<https://doi.org/10.5194/egusphere-egu24-11251>

EGU General Assembly 2024

© Author(s) 2024. This work is distributed under the Creative Commons Attribution 4.0 License.



## Microfluidic investigation of calcite dissolution with spectral induced polarization. Direct observation and petrophysical modeling.

Flore Rembert<sup>1</sup>, Philippe Leroy<sup>2</sup>, and Sophie Roman<sup>1</sup>

<sup>1</sup>Univ. Orléans, CNRS, BRGM, ISTO, UMR 7327, F-45071 Orléans, France

<sup>2</sup>BRGM, French geological survey, 45100 Orléans, France

We pioneer microscale geoelectrical acquisition with advanced microfabrication technologies to investigate hydrogeological processes using microfluidics that couples direct visualization of the pore scale dynamics with the geoelectrical response. Geoelectrical monitoring gives information at various scales ( $\mu\text{m}$  to  $\text{m}$ ) about dynamic and reactive processes involving multiphase flow, solute transport, and mineral dissolution/precipitation, which rely on microscopic interactions. Yet, the field scale geophysical survey interpretation is challenging due to the superposition of the couplings and the heterogeneity of the natural environment. We focus on developing electrical conductivity monitoring with the spectral induced polarization (SIP) method. The interpretation of the SIP signal is based on developing petrophysical models that relate the complex electrical conductivity to structural, hydrodynamical, and geochemical properties. State-of-the-art petrophysical models, however, suffer from a limited range of validity and presume many microscopic mechanisms to define macroscale parameters. Thus, direct observations of the underlying processes coupled with geoelectrical monitoring are keys to deconvolute the signature of the bio-chemo-physical mechanisms at play and for using reliable models. Microfluidic experiments enable direct visualization of flows, reactions, and transport at the pore scale thanks to transparent micromodels coupled with high-resolution imaging techniques. Micromodels are a two-dimensional representation of the porous medium, ranging in complexity from single channels to replicas of natural rocks. Cutting-edge micromodels use reactive minerals to investigate the water-mineral interactions. Here, we investigate calcite dissolution, a key multiphase process involved, e.g., in karstification. Our micromodel is a channel containing a calcite grain in the middle. Thin gold electrodes are deposited on the bottom surface of the channel for SIP monitoring. We highlight the strong correlation between SIP response and dissolution through electrical signal examination and image analysis. In particular, degassed  $\text{CO}_2$  bubbles generated by dissolution play a critical role in the acid trajectory, the evolving calcite shape, and the decreasing real part of the complex conductivity. Then, we perform image processing to retrieve petrophysical parameters such as porosity and water saturation. These parameters are used as inputs to model the complex electrical conductivity with petrophysical modeling based on the concept of equivalent circuits representing bulk and surface conductivities. We show that the petrophysical model can be applied to pore scale geoelectrical monitoring and is

consistent with optical observations. We show that the time variations are linked to partially saturated conditions, pore water composition, and evolving mineral surface state. These results demonstrate that the proposed technological advancement provides a breakthrough in understanding the subsurface processes through SIP monitoring.