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Impedance Spectroscopy for assessing the wetting conditions of reservoir rocks

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The wetting condition of reservoir rocks is a crucial parameter for the estimation of reservoir characteristics like permeability and saturation with residual oil or water. Since standard methods are often costly, at least in terms of time, we aim at assessing wettability of reservoir rocks using impedance spectroscopy (IS), a frequency dependent measurement of complex electric resistivity. This approach is promising, because IS is sensitive to the electrochemical properties of the inner surface of rocks which, on the other hand, is decisively influencing wettability.
In order to separate pure wettability effects from the influence of pore geometry and fluid electrochemistry, we first study water wet systems at full saturation exclusively. Here, we combine an experimental model system and a numerical model system to obtain a better understanding of the underlying mechanisms and quantify influencing parameters which shall contribute to an improved characterization of real reservoir rock systems.
In the first model system, we use sintered porous silica samples characterized by a well-defined and uniform chemical composition and pore structure. Here, the influence of different pore sizes and fluid conductivity on the IS spectra is studied under these specific artificial conditions in a relatively wide frequency range from 1 mHz to approximately 35 MHz.
The second model system is a numerical simulation of the charge carrier dynamics in the pore space of the porous medium. It takes into account the electrostatic interaction of the different ions with the mineral surface using a simple parametric description of the electric double layer. Therefore, it allows to quantify the influence of pore scale rock parameters on IS spectra theoretically.
We combine the resulting experimental and numerical findings which gives us the means to predict effects of pore structure and water conductivity in the context of wettability studies using IS.