

## Characterization of Carbonates by Spectral Induced Polarization

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This study investigates the complex electrical conductivity of carbonate samples by Spectral Induced Polarization (SIP). The analysis is conducted in combination with petrophysical, mineralogical and geochemical measurements. SIP is a useful tool to obtain more detailed information about rock properties and receive a more qualitative pore space characterization. Rock parameters like permeability, pore-size and -surface area can be predicted. Up to this point, sandstones or sandy materials were investigated in detail by laboratory SIP-measurements. Several robust empirical relationships were found that connect IP-signals and petrophysical parameters (surface area, surface conductivity and cation exchange capacity).

Different types of carbonates were analyzed with laboratory SIP-measurements. Rock properties like grain density, porosity, permeability and surface area were determined by petrophysical measurements. Geochemistry and mineralogy were used to differentiate the carbonate types. First results of the SIP-measurements showed polarization effects for all different types. Four different phase behavior were observed in the phase spectra. A constant phase angle, a constant slope, a combination of both and a maximum type could be identified. Each phase behavior can be assigned to the specific carbonate type used, but the constant phase occurs at two carbonate types. Further experiments were conducted to get more insight the phase behavior and get explanations.

1. Approach: An expected phase peak frequency for each sample was calculated to check if this frequency is within the measured spectrum of 2 mHz to 100 Hz.
2. Approach: Significantly reducing of the fluid conductivity to increase phase signal for a better interpretation.
3. Approach: The cation-exchange-capacity (CEC) was regarded as a factor as well. A dependence between imaginary part of conductivity and CEC was detected.
4. Approach: Imaging procedures (scanning electron microscope, x-ray computed tomography, microscopy) were used to create a qualitative image of the carbonate samples and to investigate the pore space, for example the ratio of connected to non-connected pore space.

A comparison between SIP data and the petrophysical data of the sample set showed that the phase behavior of carbonates is highly complicated and challenging compared with sandstones. It seems that there is no correlation between polarization effects and any petrophysical parameter. Ongoing investigations and measurements will be conducted to get more insight to the polarization effects of carbonates.