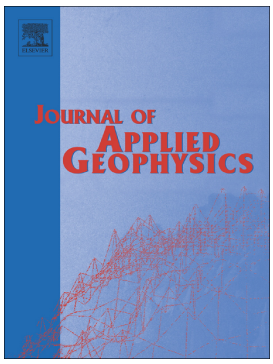

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Edith Müller-Huber, Frank Börner, Jana H. Börner, Dennis Kulke

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Combined interpretation of NMR, MICP, and SIP measurements on mud-dominated and grain-dominated carbonate rocks

Edith Müller-Huber [a,*], Frank Börner [a], Jana H. Börner [b], and Dennis Kulke[a]

[a] Department of Applied Geophysics, Technische Universität Berlin, Ernst-Reuter-Platz 1, BH 1-1, 10587 Berlin, Germany

[b] Institute of Geophysics and Geoinformatics, TU Bergakademie Freiberg, Gustav-Zeuner-Straße 12, 09596 Freiberg, Germany

Corresponding author: edith_mueller@mail.de

ABSTRACT

Carbonate formations still present a challenging target with regard to reservoir characterization as they possess a wide range of pore types and sizes as well as interconnected and isolated pore space. In this study a set of micritic and oomoldic carbonate samples was investigated with three measurement techniques (magnetic resonance (NMR), mercury intrusion (MICP), and spectral induced polarization (SIP, in a frequency range from 5 mHz to 100 Hz) which provide information about a rock's pore space indirectly based on different physical principles. The aims of the study were to combine these pieces of information to characterize the pore space of mud-dominated and grain-dominated carbonate rocks and to investigate potential correlations between pore space properties and SIP-derived parameters.

Pore body and pore throat size distributions were derived from NMR and MICP data, respectively, and interpreted in terms of dominant pore throat (r_t), pore body (r_b) radius and the r_b/r_t ratio. For validation of the NMR-derived r_b distributions, scanning electron microscope images were used for the computation of image-derived pore size distributions. The SIP data were interpreted in terms of characteristic features for oomoldic and micritic samples. Phase shift, real (σ') and imaginary part (σ'') of complex conductivity, respectively, were fitted with Cole-Cole models and the characteristic parameters relaxation time τ, chargeability m, and frequency dependence c were derived for each sample. Subsequently, these parameters were interpreted with regard to correlations with r_b, r_t, and r_b/r_t and specific surface S_{por}.

The results indicate that grain-dominated carbonates possess comparatively large radii r_b and r_t and low S_{por}, which seems to go along with sharp phase peaks (i.e. high c values) and a low absolute phase level (and therefore low chargeability m). The mud-dominated carbonates, in contrast, possess relatively small radii r_b and r_t and high S_{por} which is obviously associated with broad phase peaks (i.e. low c values) and a comparatively high phase level resulting in high m values. τ, in contrast, was found to decrease with increasing ratio r_b/r_t and may therefore have similar values in both micritic and oomoldic samples. Consequently, the results of this study contribute to a better understanding of the petrophysical properties of carbonate rocks as a function of their pore space characteristics.

KEYWORDS