IMPROVING DIELECTRIC INTERPRETATION BY CALIBRATING MATRIX PERMITTIVITY AND SOLVING DIELECTRIC MIXING LAWS WITH A NEW GRAPHICAL METHOD

Abstract:

Dielectric logging has evolved from a single-frequency mandrel tool in the 1970s to a multifrequency, fully articulated pad tool in the 2000s. Dielectric dispersion, the frequency-dependent dielectric property of sedimentary rocks, provides an additional dimension to petrophysical evaluation over broad frequency up to about 1 GHz. However, the interpretation of dielectric dispersion can be particularly difficult in organic-shale reservoirs, often due to a variety of polarization mechanisms and considerable uncertainties caused by complex mineralogy and organic matter.

In this paper, we present an integrated workflow including dielectric core analysis, processing of dielectric-dispersion logs, and petrophysical interpretation through core-log integration. We emphasize the need for accurate matrix-permittivity determination for all current interpretation methods and explore the possibility to determine matrix permittivity directly from dielectric well logs. Dielectric core analysis is used to validate the interpretation model and calibrate dielectric well logs. For instance, matrix permittivity can be calibrated in the laboratory by optimizing the dielectric constant of each mineral and kerogen. This ensures that kerogen is lump summed with the matrix for more accurate estimation of hydrocarbon volume. Multifrequency dielectric well-log data are then fitted with an appropriate mixing law or dispersion model to obtain petrophysical parameters, such as water-filled porosity, salinity, textural information, and flushed-zone resistivity. Inspired by the Pickett plot as a visual representation of the Archie equation, we propose a new graphical method that we call Complex-Domain Analysis (CDA) to solve dielectric-mixing-law equations without having to know matrix permittivity. This new method provides a simple way to determine a uniform matrix permittivity or matrix-permittivity endpoints, directly from dielectric log without a need for calculating it from mineralogy, thus very useful for quality control and dielectric interpretation immediately after logging. The integrated dielectric interpretation workflow and CDA method are demonstrated in two case studies in organic-shale reservoirs.

Bio:

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