Improved Estimation of Water Saturation in a Lower-Paleozoic European Organic-Rich Shale Gas Formation

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ABSTRACT

Unconventional resources or organic-rich shale formation generally exhibits high clay content, significant variations in lithology, rock texture, total organic carbon, accompanied by high connate water salinity, presence of disseminated pyrite grains, and low values of porosity. Subsurface electromagnetic (EM) measurements, namely galvanic resistivity, EM induction, EM propagation, and dielectric dispersion, exhibit frequency dependence due to the interfacial polarization (IP) of clay, grain surfaces, and conductive minerals. These petrophysical attributes adversely affect the log-derived water saturation estimates. The conventional subsurface EM measurement interpretation methods generate inaccurate saturation estimates in clay- and pyrite-bearing shales primarily because multifrequency conductivity and permittivity logs are interpreted separately using empirical models at a single frequency. In this work we propose an inversion-based method to process and interpret broadband EM dispersion logs. In clay and pyrite rich formation, the recently published clay and pyrite dispersion model (PS) is coupled into the inversion scheme to process logs, which takes clay and pyrite IP effects into account.