Integrated Technologies & Technical Workflow to Identify Commercial Low Resistivity Pays

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Abstract

Low-resistivity pay is generally characterized as pay zones with low apparent deep resistivity values, typically 0.5 to 5 ohm-m, with low contrast to adjacent shale resistivity. The conventional open-hole logs and traditional petrophysical interpretation workflows yield abnormally high-water saturation and lower reserves. However, such a drop in resistivity is not necessarily related to conductive saline fluids filling pore spaces. Multiple factors might contribute to the low resistivity pay challenge when using the traditional resistivity log, including but not limited to bed thickness and orientation (thin beds), grain sizes (micro-porosity), mineralogy (heavy conductive minerals), clay type, volume, and distribution. Low resistivity pay challenges can exist in sandy-shale, clastic, or carbonate reservoirs. A key to solving the low resistivity pay challenge is establishing a customizable workflow that includes multi-physics and data interpretation techniques to enhance hydrocarbon content estimates at different reservoir scales. Conventional open-hole logs provided limited answers of low resistivity pay challenges with high uncertainty. However, combining more advanced technologies reduces uncertainty and enhances the perforation selection and ultimate production performance. Many technologies have been generated over the last decades to address the low resistivity pay challenges; some of these technologies are borehole imaging, multi-component resistivity, elemental analysis, and nuclear magnetic resonance to deal with the vertical resolution, electrical anisotropy, mineralogy, and pore-size classification of low resistivity pay respectively. Two examples will be discussed. A brownfield sandy-shale low resistivity pay exhibited an apparent resistivity of ~1Ohm with an apparent high-water saturation was re-evaluated using the advanced technologies (Borehole image, acoustic, elemental, and magnetic resonance tools) in the LRP technical workflow. This new evaluation identified zonal perforations that resulted in commercial production that subsequently increased 4 fold after recommended stimulation. Another case study of a micro-porous gas bearing carbonate reservoir that exhibits abnormally high porosity, low permeability, and low apparent resistivity of ~2Ohm has been re-evaluated using core, borehole image, magnetic resonance, and elemental analysis tools in the LRP integrated workflow to address the potential and recommended a stimulation technique for achieving commercial and sustainable production. The preliminary zonal perforation resulted in low-rate short-living production; however, the information was used to design a hydraulic stimulation to ensure faster well cleanup, reservoir damage reduction, and maximized fracture conductivity, resulting in a significant 39 fold improvement in productivity after the treatment.