T₁ Data Helps Operator Resolve Pore Size Variation in Complex Carbonate Formation

**OVERVIEW**

An operator in the Middle East wanted to compare the ability of T₁ data from the MRIL®-WD™ magnetic resonance logging-while-drilling (LWD) sensor to resolve pore size variations within a complex carbonate reservoir with high-quality wireline nuclear magnetic resonance (NMR) data, in a 6½-in. vertical well. In order to enhance spectral resolution for fluids with slow relaxation times within the field, customized activation times were developed for the wireline tools, which in turn were calibrated with special core analysis data. For the LWD tool to provide a useable resolution of the slow relaxation times within the reservoir, it was essential that the data not be impacted by lateral vibration or axial motion effects.

The vertical well was used for a back-to-back comparison between the NMR spectra acquired by the wireline tool and the T₁ spectra acquired by the 4¼-in. MRIL-WD tool. The while-drilling acquired T₁ distributions and associated partial porosities were also compared with those acquired during a wipe run to verify that the LWD data was not negatively affected by the vibration and tool motion encountered in the drilling environment.

**SOLUTION**

Sperry Drilling collaborated and engineered a solution that included:

- 4¼-in. MRIL®-WD™ magnetic resonance imaging logging-while-drilling sensor, with customized cutoffs to differentiate macroporosity from microporosity
- Wireline nuclear magnet resonance (NMR) imaging
- Wireline formation pressure testing
- Macroporosity input into Coates equation to determine permeability over zone with the largest macroporosity volume

**RESULTS**

- Excellent correlation between MRIL-WD and wireline pore size evaluation
- Identified largest pores associated with decreased pore volume, per wireline and LWD analysis
- Confirmed permeability calculations from wireline and LWD improved rock quality assessment compared to conventional analysis
- Enhanced reservoir understanding for better well placement decision-making
REAL-TIME T₁ DISTRIBUTION DATA IMPROVES WELL PLACEMENT

The real-time T₁ distribution transmitted while drilling was compared with the distribution transmitted during a wipe pass, along with the corresponding memory distributions. The excellent agreement between all data sets provided the operator with the confidence that the while-drilling T₁ distributions and the associated petrophysical analysis provided a powerful decision-making tool for well placement operations.

Having verified the suitability of the 4¾-in. MRIL®-WD™ data for advanced pore typing in carbonates, the operator acknowledged the wide range of additional applications that this service can address in the region to enhance petrophysical evaluation and fluid identification. Other applications that can benefit from using T₁ data include shale volume calculation; determination of bound and free fluid volumes; source-less, lithology-independent porosity determination; permeability estimation; moveable water detection; and the characterization of oil viscosity in the presence of heavy oil or tar.

CASE STUDY

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Comparison of wireline data and MRIL-WDT, data and their associated field-specific pore volume and permeability analyses. Results show the increase in pore size in the dolomitic interval is associated with a decrease in pore volume but shows the highest mobilities.