MATURE FIELDS

CASE STUDY

T_1 Data Helps Operator Resolve Pore Size Variation in Complex Carbonate Formation

4¾-IN. MRIL®-WD™ LOGGING-WHILE-DRILLING SENSOR DELIVERS T_1 DATA FOR OPTIMUM WELL PLACEMENT IN A MATURE FIELD

MIDDLE EAST

CHALLENGE

- Perform advanced carbonate pore typing in complex carbonate reservoir
- Compare LWD data with wireline data and associated petrophysical analysis

SOLUTION

Sperry Drilling collaborated and engineered a solution that included:

- 4¾-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

OVERVIEW

An operator in the Middle East wanted to compare the ability of T_1 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 6⅛-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 T_1 spectra acquired by the 4¾-in. MRIL-WD tool. The while-drilling acquired T_1 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.

LWD T_1 DATA RESOLVES PORE SIZE VARIATION & ENHANCES RESERVOIR UNDERSTADNING

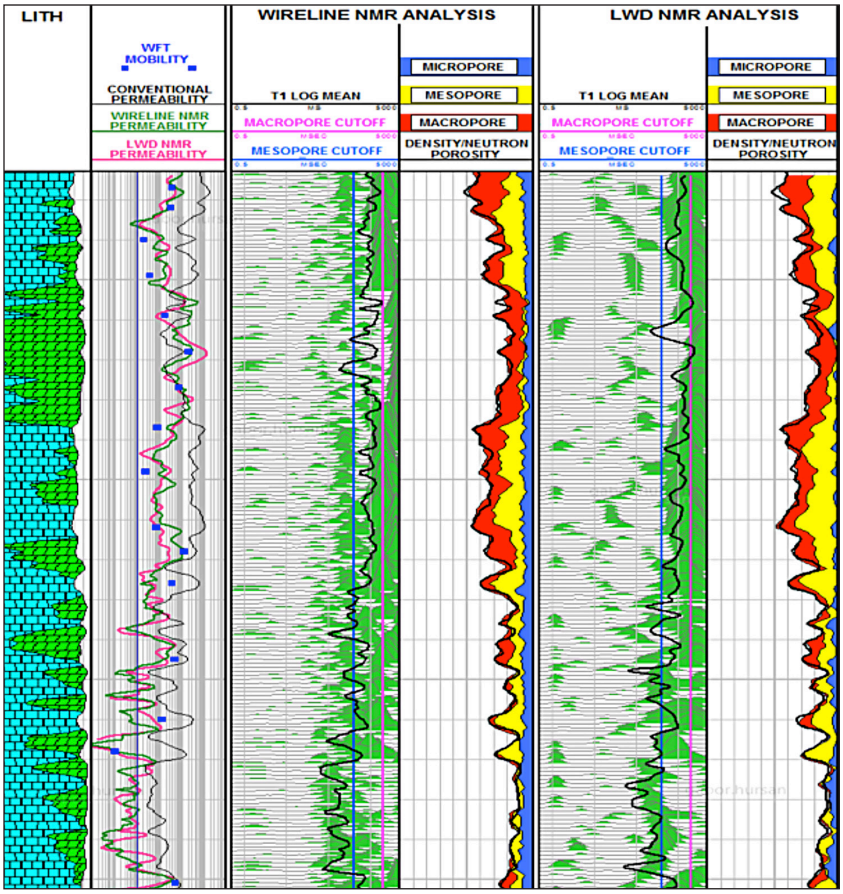
In collaboration with the operator, Sperry Drilling used the MRIL-WD Job Planner to select cutoffs that accentuated the carbonate macroporosity: one cutoff with T_1 = 440 ms and another with T_1 = 2 sec. For the advanced carbonate pore typing, the amount of macropores was approximated by fluid volumes with T_1 > 2 sec, and the micropore volume was quantified by summing the fluids with T_1 < 440 ms. The data from both wireline and LWD indicated that the largest pores were in a dolomitized interval between two high-porosity lobes, with the dolomite showing a decrease in pore volume. Wireline formation pressure testing indicated that this zone had the highest mobilities, despite the relatively low porosity; and the permeability calculated using the macroporosity input into the Coates equation showed reasonable consistency with the mobility data.

When compared to the conventional permeability calculations, the wireline and LWD logs both showed a significant enhancement to the rock quality assessment. The successful comparison with wireline interpretation confirmed to the operator that the 4¾-in. MRIL-WD sensor enhances reservoir understanding by resolving pore size variations in the most complex carbonate pore system; thereby, helping to maximize asset value.

REAL-TIME T_1 DISTRIBUTION DATA IMPROVES WELL PLACEMENT

The real-time T_1 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 T_1 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 T_1 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.



Comparison of wireline data and MRIL-WD T_1 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.

This case study includes data from technical paper SPWLA-2018-LL, prepared for presentation at the SPWLA 59th Annual Logging Symposium held in London, United Kingdom, June 2018.

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