Field Implementation of LWD NMR ROP Correction Enables Faster Drilling

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Abstract:

Logging-while-drilling (LWD) nuclear magnetic resonance (NMR) data acquisition has historically been a limiting factor in drilling performance. Increasing the rate of penetration (ROP) beyond a certain threshold leads to overestimated NMR porosity measurement. This condition exists because the motion of the NMR tool with its magnetic field profile creates time-dependent formation magnetizations, which are not considered in the standard data processing. A newly designed and implemented ROP correction for the slimhole LWD NMR tool results in doubling the ROP.

A thorough understanding of the NMR spin-dynamics physics in time-dependent magnetic fields, in conjunction with the detailed knowledge of the slimhole LWD NMR tool architecture, underpins the reliability of the ROP correction. The central point of this correction is to characterize two spin types during tool motion; i.e., those spins leaving the NMR sensitive region, and the spins coming into the NMR sensitive region. Keeping track of these spins during NMR measurements allows for deriving the correct porosity from motion-affected NMR data. The ROP correction was developed based on extensive computer simulations, which were verified by laboratory experiments.

Field testing was performed to validate the ROP correction algorithm and the field processing workflow. The ROP correction was tested in several wells. In two wells, relogging at multiple ROP levels enabled testing the correction algorithm while other parameters were carefully controlled. The ROP correction field tests defined an operational envelope for ROP vs. formation properties (i.e., longest T1 longitudinal relaxation time) for the slimhole LWD NMR tool. The ROP correction allowed for doubling the logging speed from 75 ft/hr without correction to at least 150 ft/hr with correction in microporous reservoirs where the T1 longitudinal polarization time of most formation fluids does not exceed 5 sec. In challenging carbonate reservoirs whose T1 exceeds 5 sec, the ROP correction enabled a drilling speed increase from 65 ft/hr to at least 110 ft/hr, a 70% increase in ROP. Additional field testing is being performed to expand the ROP envelope even further. After completing the field-testing phase, the ROP correction was implemented in real time in several fields where it enabled drilling the wells with record ROP for LWD NMR bottomhole assemblies (BHA) in these fields, despite the slow polarization buildup in the macroporous carbonate reservoirs.

Based on advanced tool physics modeling, the novel slimhole LWD NMR ROP correction produced an ROP increase of 70 to 100%, even in slow-relaxing formations such as macroporous carbonates. The correction is available both for real time and recorded mode data processing, enabling real-time decision making.

Bio:

Gabor Hursan is a petrophysicist at the Reservoir Description Division in Saudi Aramco. As the company's lead SME in NMR logging, he is ultimately responsible for NMR data acquisition and petrophysical analysis. Previously, he worked as a scientist at Baker Hughes for 10 years in various capacities on NMR interpretation technology development. He has an MS degree from the University of Miskolc, Hungary and a PhD from the University of Utah, both in Geophysics. He published over 40 papers and patents, teaches classes in NMR logging and serves SPE and SPWLA as reviewer for technical publications and is a founding member of the SPWLA's NMR Special Interest Group.