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FORMATION EVALUATION WITH NMR, RESISTIVITY AND PRESSURE DATA – A CASE STUDY OF A CARBONATE OILFIELD OFFSHORE WEST AFRICA

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Abstract:

In this paper, we examine fluids interpretation techniques in a prolific oilfield in offshore West Africa. The reservoir rocks are dominated by Cretaceous limestone, with a small fraction of dolomite and siliciclastic minerals. Due to concerns of radiation hazard, the drilling team has selected a sourceless logging program, consisting of LWD NMR, resistivity and formation tester, to log the reservoir section in 6.5'' holes. Therefore, standard log interpretation, which relies on multi-mineral analysis, is no longer viable. The purpose of this study is to answer questions related to asset appraisal and development with these limited measurements.

Whole cores were collected from both of the geological structures of the oilfield and the lab measured porosity, permeability, water salinity, Archie m and n and DeanStark Sw. Comparison of core and NMR log indicates that NMR total porosity is not affected by hydrocarbon in the pore space. We use a statistical method called factor analysis to deconvolve independent fluid modes, such as clay bound water, capillary bound water and oil+oil-based mud (OBM) filtrate, from the T2 distribution. The number of modes to solve for is determined by principal component analysis. The free fluid T2 cutoff is chosen based on the identified modes. The NMR irreducible water saturation ($Swirr$) computed with this cutoff agrees with Dean-Stark Sw, measured on core samples assumed to be fully invaded by OBM. Continuous Sw is calculated with Archie's equation with lab-measured parameters and validated against DeanStark Sw above the transition zone. The Timur-Coates model is used to estimate matrix permeability, using core-calibrated multiplier and the T2 cutoff from factor analysis. The permeability, Sw and $Swirr$ curves are then used to compute continuous effective permeability to water and oil.

The first application of this interpretation workflow is to confirm the free water level (FWL) derived from pressure gradients. We found the Sw profile largely controlled by heterogeneity in rock textures. Good quality rocks have negligible transitions zones and contain little free water above FWL. Poor-quality rocks have longer transition zones, but the relative permeability to water is too low for the water to flow, as confirmed by production. Pressure depletion suggests excellent connectivity within the reservoir, so these poor-quality rocks are considered a local feature. Log analysis confirms the reservoir wide FWL, which translates to a significantly increased OOIP over initial estimation. The second application is perforation design. Zones with good porosity and low mobile water volume are selected for perforation and a safe distance is maintained from FWL. As a result, all producer wells exhibit zero water cut.

Bio:

Ting Li is a senior petrophysicist with Chevron. He began his career as a research scientist at Schlumberger-Doll Research in 2008 and spent 5 years working on nuclear spectroscopy, NMR and integrated interpretation of unconventional reservoirs. In 2013, he worked as a domain champion of LWD petrophysics for Schlumberger Drilling and Measurements, where he supervised high-tier LWD sales and operations in north China. In 2015, he became a senior interpretation engineer at Schlumberger engineering center in Sugar Land, Texas, where he helped introduce the next-generation cased-hole pulsed neutron tool to the market. In 2019, he joined Chevron ETC as a senior petrophysicist. Ting holds a Master of Science degree in computer science from the University of New Mexico, USA. He is a member of SPE and SPWLA.