NMR Fluid Substitution – Pursuing the Fundamental Controlling Parameters of a Low-Mobility Reservoir

Speaker: **Søren Amdi Christensen, AkerBP**

Abstract:

E&P is continuously advancing towards developing reservoirs of increasingly lower quality. This talk is particularly relevant in the context of formation evaluation (FE) of low mobility (unconventional) reservoirs. When faced with this challenge, interpreters must scrutinize the commonly used FE methodologies and question their suitability for the task. This presentation addresses the fundamental considerations made while developing several very low mobility reservoirs and explains the solutions derived. The objective of this talk is to discuss the assumptions of the methodologies that petrophysicists typically use without question and to present a solution to the shortcomings of these methodologies based on NMR.

Downhole petrophysical measurements are typically governed by a combination of rock and fluid properties. The concept of fluid substitution (FS) is to create a measurement response at a different saturation than at which data are acquired downhole. In the context of nuclear magnetic resonance (NMR), FS is used to eliminate the hydrocarbon (HC) contribution from T1 and T2 distributions and thus to establish the pure response of a water-filled rock.

In 2015, Christensen et al. presented the first study conducting successful FS for a chalk reservoir. Based on theoretic considerations and laboratory measurements, the T2 geometric mean (T2gm) of the water-saturated rock is determined and converted into dominant pore throat radius (PTR) and Klinkenberg permeability (Kk). The objective of this is to get a grip on the fundamental parameters controlling flow properties and the distribution of saturation in a North Sea low-mobility chalk reservoir, namely pore throat size and capillary entry pressure (Pce).

In the present study, the established FS methodology is applied to a chalk reservoir with 40 years of production history. In this case, however, the very basis of the FS model was seen to be challenged by the core data established for calibration. The core T2 and PTR distribution data acquired for calibrating the calculation of PTR and Kk, was observed to deviate from the general and expected simple chalk behaviour. Despite these complications, a modified workflow was developed, enabling a successful calibration and application of the FS workflow.

The NMR FS methodology appears to be more versatile than originally concluded. The established model has shown the capability of identifying important flow units that otherwise would not have been appreciated as well as intervals with less favourable potential from a flow perspective that otherwise would have been modelled as “normal” rock based on the porosity-permeability transform established for the field.

In addition, the method has shown the ability to identifying rock with changed pore morphology due to compaction as well as revealing bad hole conditions that may not be readily appreciated from other downhole data. Under these circumstances the model fails to deliver results in line with the calibration, but the flawed output can be translated into information in terms of compaction and ongoing hole enlargement and thus the method has shown a new application.

Bio:

Søren Amdi Christensen is petrophysical consultant working for AkerBP on the Valhall field. Having done a major part of his studies at Bergen University, Norway, he received his MSc degree in petrophysics and reservoir geology from Århus University, Denmark, in 1996. During his professional career he has worked as staff or consultant for various companies including DONG Energy, HESS, SAUDI ARAMCO. In recent years, his experience has branched out to include petrophysical consultancy for start-up companies in the geothermal- and CCS domain also. He is a data integration specialist with a special interest in the application of NMR. He has more than 25 years of experience with chalk evaluation and chalk field reservoir development. Formation evaluation and development of low-mobility reservoirs is a primary technical interest, and he is presently involved in unlocking reserves from an ultra-low-mobility North Sea Diatomite reservoir for AkerBP leveraging his low-mobility experience from chalk.