NMR Petrophysics

(GeoNeurale/Halliburton)

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Determination of porosity, bound and movable fluids, pore size distribution, fluid identification, oil viscosity, permeability and capillary pressure are essential petrophysical parameters for reservoir characterization and formation evaluation. Among logging technologies, low field NMR technology has a proven record of successful applications delivering these key parameters, not only at laboratory scale but also as well logging service, both wireline and LWD.

The very raw NMR signal is called Echo Train, which describes the loss of magnetization of the Hydrogen protons. It is typically described as a multi-exponential decay that is transformed after a Laplace Inversion into a distribution of relaxation times -the T1 or T2 spectra. T1 characterizes the longitudinal and T2 the transversal relaxation.

As the NMR signal is generated from Hydrogen protons a in a rock sample saturated with water, hydrocarbons or both, the area under the NMR T1 or T2 spectra, is equivalent to sample total porosity[1]. In addition, the NMR spectra yield information about the volume of fluid that can be produced (Free Fluid Index, FFI) or is bound to the rock either due to electrical (Clay Bound Water, CBW) or to capillary forces (Bound Volume Index, BVI). The partition of the NMR porosity, which is obtained using cut-off values, is unique among porosity tools and differentiates NMR from Density and Neutron logging technologies, with the additional operational advantage that NMR doesn't use any radioactive sources. Figure below shows the typical NMR porosity partition.

Permeability is another very important parameter that can be calculated from NMR porosity variables through empirical equations. Following the Timur-Coates equation, the NMR-permeability is modelled as being proportionality to porosity and free fluid and inversely proportional to the bound fluid. For higher accuracy permeability models can be calibrated based on lab measurements.

When the rock is saturated with water, the NMR spectra typically deliver the pore size distributions that can also further use to model capillary pressure, rock types and grain size distributions.

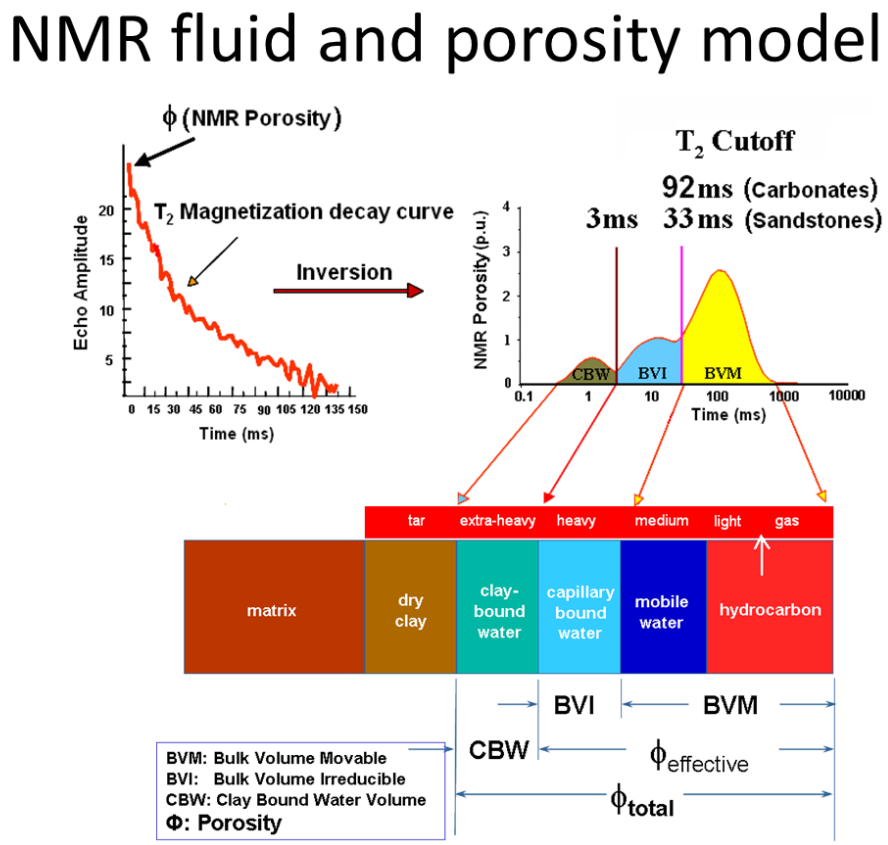
NMR fluid typing takes advantage of the fact that hydrocarbon viscosities correlated over a broad interval with the T1 or T2 relaxation times. It allows the identification of heavy, medium and light oils. Advance interpretations based on so called 2DNMR and new machine learning methods improved fluid typing when gas, water, oil and mud filtrate may be present and share similar T1 or T2 responses.

This NMR course will lead the participants through this very exciting technology. It starts with refreshing basic concepts of NMR technique and continues with an overview of the logging technologies currently used by service companies in wireline and LWD markets, petrophysical NMR model and evaluation

[1] Extra-Heavy Oil, Tar mats and Gas layers need special processing

techniques, case studies applications in sand stone and carbonate reservoirs and ends with a review of recent Machine Learning techniques applied in NMR data processing.

Link: http://www.searchanddiscovery.com/pdfz/documents/2010/40519romero/romero_OP.pdf.html



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