COUPLED NMR LOG/LAB INVESTIGATION OF CARBONATES: AN APPLICATION FOR HYDROGEOLOGICAL PURPOSE TO THE JURASSIC LIMESTONE OF THE PARIS BASIN (FRANCE)

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NMR (Nuclear Magnetic Resonance) logs are now commonly used in oil and gas exploration, and provide crucial data such as a continuous record of porosity, permeability, pore-size distribution, fluid saturation (e.g. Nurmi & Standen, 1997). Integrated with MICP (Mercury Injection Capillary Pressure), NMR brings key insights about the pore network and then becomes of primary importance for rock-typing analysis independently from depositional facies. However, a genetic geological knowledge remains necessary to interpret NMR data. In the present study, we propose an integration of some recent advances (e.g. Westphal et al., 2005) to optimise the use of NMR logs for carbonate reservoir characterisation.

In the Eastern Paris Basin, the Andra (French National Radioactive Waste Management Agency) evaluates the deep geological repository of radioactive wastes in an Underground Research Laboratory (URL) located in a 150m thick Callovian-Oxfordian claystone Formation. The latter is bounded by the Middle and Upper Jurassic shallow-marine carbonate Formations. For safety reasons, one of the key Andra concerns is to constrain the past and present fluid-flows in these Formations, thus to characterise as precisely as possible the petrophysical properties and their distribution. A complete logging survey was performed including classical logs, hydrological well tests, and a complete set of NMR logs. RCA (Routine Core Analysis) on core plugs and cuttings were also performed to constrain the NMR log derived calculations. NMR derived porosity is very close to the RCA data, but permeability calculation is less consistent. Indeed, the parameters chosen for SDR (Sclumberger Doll Research) equation were initially tuned to provide a best permeability estimate in the Callovian-Oxfordian claystone. Consequently, they were not adapted to the surrounding limestones, especially in the porous water-producing levels. Using petrography, MICP, and NMR laboratory tests from core plugs, we defined precisely the pore-network of the latter porous levels. Then using the T_2 distribution continuous logs, stratigraphic intervals with dominant pore-types were defined, forming a discrete log for each well. Following the work of Westphal et al. (2005), we then changed the parameters of the K_{SDR} equation according to the dominant pore type per zone to optimise the permeability calculation. This resulted in a considerable improvement of a continuous permeability estimation in the studied wells. However, technical problems, such as the effect of oil-based drilling mud, were revealed by the comparison between NMR log and lab acquisition on the same levels. They hampered an absolutely enthusiastic achievement of this study but allow to continue some researches to improve the method.

Nurmi, R., Standen, E., 1997. Carbonates, the inside story. Middle East Eval. Rev. 18, 28–41.

Westphal, H., et al.., 2005. NMR measurements in carbonate rocks: problems and an approach to a solution. Pure Appl. Geophys. 162, 549–570