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Analysis of pore connectivity in oil reservoir rocks by NMR Exchange rates - a potential indicator of permeability and economic viability of an oil reservoir

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Nuclear Magnetic Resonance (NMR) has made significant contributions to various areas of research, development, and innovation (RDI), both in academia and industry, as well as in projects that bridge these two sectors. In the case of our research group, the High-Resolution NMR Spectroscopy Laboratory (LEAR-IFSC/USP), we have been engaged in RDI over the past 35 years, preserving the theoretical aspects of the technique, which serve as a foundation for the development of new methodologies, advanced instrumentation, and studies of materials in the liquid or solid state. Within this perspective, this master's project aims to study the connectivity of the porous medium in petroleum reservoir rocks through Relaxation Exchange NMR techniques, which are indicators of reservoir permeability and economic viability. Among the porous media studied, we highlight sandstone and carbonate rocks, which are currently being evaluated for their use in geological CO_2 sequestration. (1) Thus, in a field of 0.5 T (frequency of 20MHz for the ^1H nucleus), a filter acts on the fluid molecules saturating the porous medium, attenuating the signal from each pore depending on its T_2. Initially, an experiment is conducted without a filter to observe the original signal decay, which is used as a reference for the other experiments; then, a filter time is chosen that completely suppresses the signal from the smallest pore. However, if there is an exchange, it is expected that at the end of the experiment, magnetization will reappear in the smaller pore, from which important petrophysical parameters such as permeability and medium connectivity can be obtained. This experimental method was named T_2 Filtered T_2-T_2 Exchange, a proposal from our group as a result of the implementation of the T_2-T_2 Exchange experiment proposed by Jing-Huei Lee. (2-3) In the case of sandstone reservoirs, there is greater homogeneity in petrophysical properties; however, in the case of carbonate reservoirs, there is significant heterogeneity, with pores ranging from nanometers to millimeters, so that the connectivity between macroporosity is often defined by microporosity. A challenge lies in estimating the parameters related to exchange rates. This is because the amount of magnetization present in microporosity is often less than 5% of the total signal and is strongly affected by noise in the signal. Thus, through the use of computed tomography with synchrotron radiation, we will also seek to access pore distribution with a resolution of 500 nm, in order to reduce the physical-computational uncertainties of NMR experiment simulations and validate the proposed T_2 Filtered T_2-T_2 Exchange experiment.

Palavras-chave: Relaxation exchange NMR; Connectivity; Permeability.

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