# Dynamics and wettability of petroleum fluids confined in shale-oil rocks:
# A fast field cycling NMR relaxometry approach

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It is critical to probe *in situ* the dynamics and wettability of oil, water and gas trapped in the complex microstructure of shale-oil rocks. However, usual techniques cannot separate these fluids in shale rocks. In this lecture, we present multi-frequency *(FFC)* (Fig. 1a) and multi-dimensional nuclear magnetic relaxation *(2-D $T_1$-$T_2$)* (Fig. 1b) techniques for probing these dynamics. The frequency dispersion behaviours of the longitudinal relaxation rates *$1/T_1$* for oil and water confined in microporous shales are interpreted through a relaxation model showing *1-D* (oil) and *2-D* (water) diffusing phases confined within the organic kerogen and mineral layers, respectively[1]. We probe the average hopping and residence times of these fluids at pore surfaces. We assign the different signals to water and oil at both organic and mineral pore surfaces for characterizing their local wettability. This allows interpreting our *2-D $T_1$-$T_2$* correlation spectra that could be made down-hole, thus giving invaluable tool for investigating oil and gas recovery on these important porous rocks.
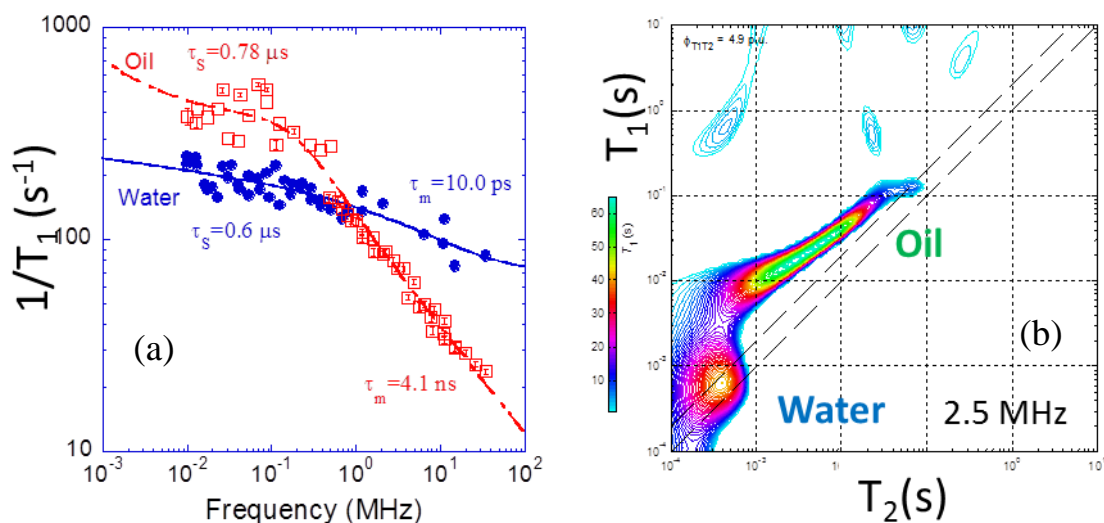


Fig. 1 (a) Measured proton spin−lattice relaxation rates constants *$1/T_1$* as a function of the proton Larmor frequency for an oil/water/air shale. The continuous (water) and dashed (oil) lines are the best fits obtained with our relaxation theory[1]. (b) Two-dimensional $T_1$−$T_2$ spin correlation maps made at 2.5 MHz of oil/water/air shale as-received. A color code index is given for estimating the relative intensities of the different peaks.

[1] J.-P. Korb, B. Nicot, A. Louis-Joseph, S. Bubici, and G. Ferrante  *J. Phys. Chem. C.* **2014,** 118, 23212-23218.

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