Improving Reliability of Surface NMR Relaxation Time Measurements: Composite Pulses to Quantify Background Magnetic Field Inhomogeneity

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We develop a technique to quantify background magnetic field inhomogeneity leading to more robust estimates of Nuclear Magnetic Relaxation (NMR) time constants. This will potentially allow surface based NMR measurements to begin to utilize empirical relationships developed in the petroleum industry to estimate permeability. Power constraints generally limit surface based measurements to a single perturbing pulse, contrary to logging NMR where long trains of perturbing pulses may be applied. This leads to a fundamental difference between the parameters measured in surface and logging NMR, T_2^* and T_2, respectively. Ideally, surface NMR would estimate T_2 directly but a lack of perturbing pulses results in T_2^* being very susceptible to background magnetic field inhomogeneity, leading to faster measured decays.

We develop a technique utilizing composite pulses to estimate the background magnetic field distribution. Composite pulses are commonly used in NMR spectroscopy and magnetic resonance imaging in order to alleviate off-resonance effects arising from background magnetic field inhomogeneity. Instead, we propose to develop a suite of composite pulses that exploit off-resonance effects to varying degrees. From the observed extent of off-resonance effects occurring in each composite pulses we estimate a distribution of the background magnetic fields present. The estimated background magnetic field distribution is then used to predict the extent of dephasing present in the T_2^* decay. This allows the T_2 decay to be predicted.

A major advantage of the presented technique is that it provides estimates of T_2, the more reliable permeability indicator, without demanding the need for improvements in the available power in surface NMR. This leads to more reliable T_2 estimates and subsequently improved permeability estimates allowing surface NMR to provide a more complete aquifer characterization.