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Investigation of porous systems by Earth Field NMR

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Nuclear Magnetic Resonance (NMR) has proved to be a valuable non-invasive technique for probing porous media [1]. A ^{1}H NMR experiment provides information on the amount of hydrogen in the pore space and is thus a measure of porosity. The decay of the proton magnetisation depends on the length scales of the pores and on the pore-fluid-grain interactions. The two time constants associated with this decay are the longitudinal time constant T_1, describing the decay along the magnetic field direction, and the transversal time constant T_2, describing the dephasing of the precessing protons in the plane perpendicular to the magnetic field direction.

In conventional NMR experiments those relaxation times are measured in high magnetic fields ranging from about 0.01 T up to 10 T, corresponding with Larmor frequencies (ω_L) of the proton up to few hundreds of MHz, given by:

$$\omega_L = \gamma B$$

with γ: gyromagnetic ratio of the proton

The high magnetic field (bringing along complex and expensive devices) is replaced in this work by the weak but very homogeneous Earth's magnetic field (B_0 = 50 μT). The poor sensitivity arising from the low Larmor frequency is compensated by the large homogeneity that permits the use of large samples and by enhancing the initial magnetisation by means of a pre-polarizing pulse [2]. The large homogeneity makes it also possible to directly derive the transversal relaxation times from the digitised free induction decay (FID) signal with a signal to noise ratio of about 100 without need for pulse sequences as in conventional NMR techniques.

The Earth Field NMR device is based on the design presented in [3] and built in a way that it can be used in a normal laboratory environment with its natural occurring interfering influences such as electric wires and metal from reinforced concrete or furniture. The first results of modelled soils (randomly packed glass beads) and sand are promising and comparable with results from the conventional high field NMR applications.

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[2] M. Packard and R.Varian, Phys. Rev. **93**, 941 (1954)

[3] R. Goedecke, Ph.D. Thesis, University of Bremen (1993)