# NUCLEAR MAGNETIC RESONANCE TO USE IN ANALYSIS OF PETROPHYSICAL PARAMETERS OF ROCKS

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The phenomenon of nuclear magnetic resonance has become a valuable tool in applied geophysics, because of significant progress in computer technology. Using NMR as a laboratory study with cores analysis and well-logging has been permitted to get information about rocks, inaccessible with other methods. It allows to evaluate the several parameters as: porosity, volume of water saturated pore space included clay bound water, capillary bound water and crystalline water of hydration, such as in gypsum - $CaSO_4*2H_2O$, permeability, pore size, oil viscosity [3].

**Relaxation, pore size**

The NMR measurement consist in registration the longitudinal and the transverse relaxation times. NMR signal analysis is complicated, because of internal pore size geometry. The relaxation mechanism dependents on surface relaxation type, pore shape and size and interaction contact between pores and molecular diffusion. During the signal analysis has been assumed that the $T_2$ (transverse relaxation time constant) is proportional to pore size and pores sides are smooth and homogeneous [2].

**Porosity**

NMR measurements make possible the qualification of hydrogen content in rocks. Hydrogen can exist as water or hydrocarbons filling pore space in the form of hydroxyl groups and clay bound water. The NMR measurement is the only method using in applied geophysics, which make possible to differentiate the total porosity, effective porosity and free fluid porosity. The division between capillary bound water and free fluid is referred to as the $T_2$ cutoff. Generally speaking, the $T_2$ cutoff for sandstones is around 33ms [7].

**Permeability**

The NMR estimation of permeability was based on theoretical models. They show that permeability increases with both increasing porosity and increasing pore size [4, 6]. Three related kinds of permeability models have been developed [1, 5]:

1. Coates model : $K_{prNMR} = C[(\frac{\Phi}{10})^a(\frac{\Phi_3}{\Phi_1+\Phi_2})^b]$
2. Clay bound water influence model: $K_{prNMR} = C[(\frac{\Phi}{10})^a(\frac{\Phi-\Phi_1}{\Phi_1})^b]$
3. SDR (The Schlumberger – Doll Research) model: $K_{prNMR} = C[(\frac{\Phi}{100})^a(T_{2\log})^b]$

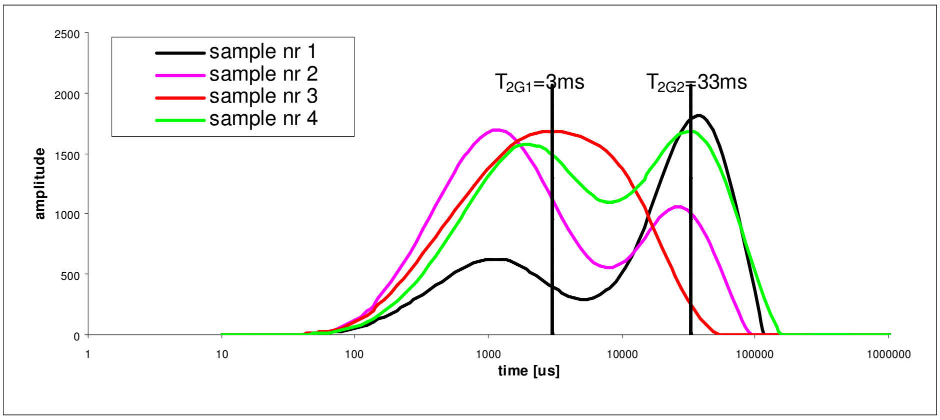
   where: $K_{prNMR}$ – permeability [mD],
   $\Phi$ – total porosity [%],
   $\Phi_1$ – clay bound water saturation [%],
   $\Phi_2$ – capillary bound water saturation [%],
   $\Phi_3$ – free fluid saturation [%],
   $T_{2log}$ – logarithmic mean $T_2$

Proton relaxation times were measured on a spectrometer MARAN ULTRA 23MHz of English company Resonance Instruments Ltd. The spectrometer works at the induction of 0,56 T, the temperature of measurements is 35$^o$C.

**Table.1** Porosity analysis, pore space saturation and permeability in the Miocene sandstones samples.

| | Miocene Sandstone | | | |
|---|---|---|---|---|
| | Nr 1 | Nr 2 | Nr 3 | Nr 4 |
| Total porosity [%] | **11** | **14,5** | **14,8** | **17,9** |
| Effective porosity[%] | **7,6** | **5,5** | **6,5** | **10,5** |
| Clay bound water saturation [%] | **31** | **62** | **56** | **41,3** |
| Capillary bound water saturation [%] | **37** | **29** | **42,6** | **39,2** |
| Free fluid saturation [%] | **32** | **9** | **1,4** | **19,5** |
| Permeability coefficient: Coates model [mD] | **7,03** | **5,3** | **0,93** | **30,52** |
| Permeability coefficient: Clay bound water influence model [mD] | **15,48** | **4,5** | **6,75** | **25,2** |
| Permeability coefficient: SDR (The Schlumberger-Doll Research) model [mD] | **5,2** | **3,69** | **4,01** | **20,22** |
| Permeability coefficient: gazometry [mD] | **20,67** | **9,27** | **0,93** | **12,04** |

Fig. 1 The $T_2$ distribution for Miocene sandstones.




NMR experiment makes possible separation between perspective and non-perspective area for accumulation and production water and hydrocarbons. All Miocene sandstones samples have a similar total porosity. Using NMR we can separate area where are good reservoir properties (sample nr 4) with high free fluid index and high permeability from non – perspective, water – proof area (sample nr 3).

NMR method can provide three types of information, each of which makes this tool unique among geophysics devices: information about the quantities of the fluids in the rock, information about the properties of these fluids, information about the sizes of the pores that contain these fluids. NMR porosity is independent of the lithology of the rock matrix and can be validated by comparing laboratory NMR measurements on cores with conventional laboratory porosity measurements.

**References:**

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