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Low field NMR surface relaxivity studies of chalk and argillaceous sandstones

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This paper provides an insight into how the surface relaxivity of minerals constituting rocks are affected by changes in temperature and Larmor frequency. This is relevant for connecting conventional rock core testing data to reservoir logging data.

In the present study, we perform laboratory NMR T_2 measurements on Gorm field chalk, Stevns Chalk, Solsort field greensand and Berea sandstone so as to determine the surface relaxivity, ρ , of the rock forming minerals. Transverse relaxation rate, $1/T_2$ is proportional to ρ and the surface-to-volume ratio (S/V) of the pore space [1]:

$$\frac{1}{T_2} = \rho_2 \frac{S}{V} \quad (1)$$

Paramagnetic minerals in contact with the water accelerate the surface transverse relaxation (equation 1) at higher frequencies, so T_2 distributions at Larmor frequency 2 and 20 MHz at 40°C were used to identify the presence of paramagnetic minerals in water saturated rocks. Therefore, the surface relaxivity of the respectively purely calcitic and purely quartzitic Stevns chalk and Berea sandstone proved not to be affected by the changes in frequency. By contrast, paramagnetic minerals in the Gorm field chalk and Solsort field greensand resulted in higher values of ρ when the NMR measurements were performed at higher Larmor frequency (Figure 1).

T_2 distributions at temperatures ranging from 10 to 70°C provide a valuable connection between lab and field transverse relaxation measurements. The T_2 distributions illustrate that ρ for calcite tends to decrease with temperature whereas ρ for quartz tends to increase with temperature. These changes may be used to describe changes in the porosity and pore size distribution obtained in the lab, compared to those in the logs.

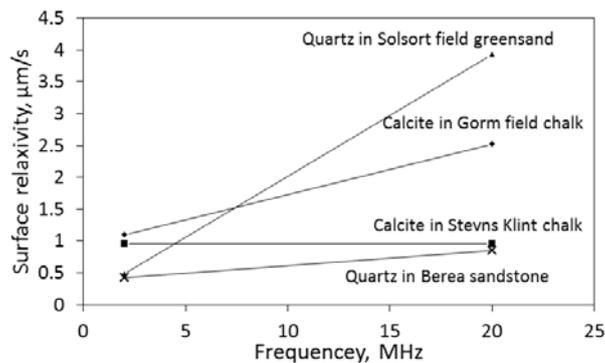


Figure 1 – Changes in the surface relaxivity of the main minerals constituting the rocks under investigation versus the Larmor frequency of the measurements. The T_2 value was acquired at 2 and 20 MHz at 40°C.

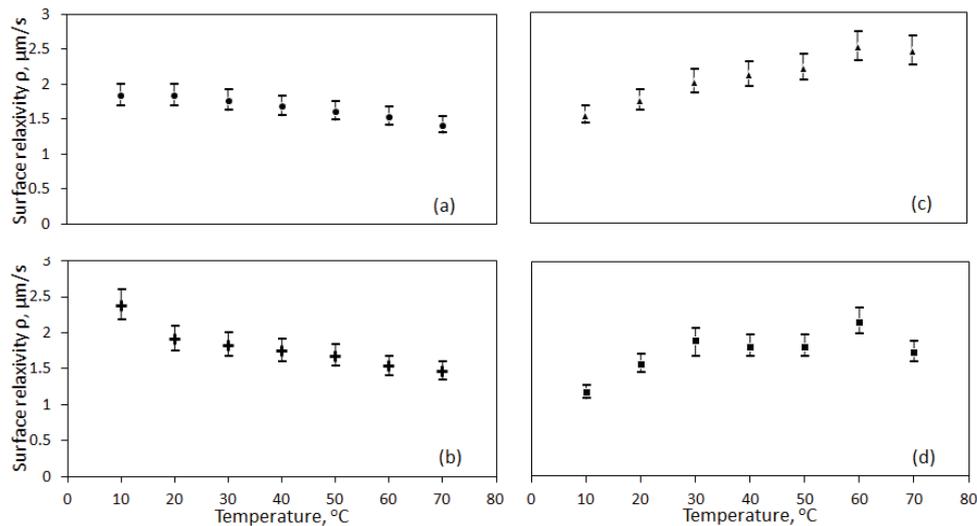


Figure 2 – The surface relaxivity of calcite in (a) Gorm field chalk and (b) Stevns Klint chalk, quartz in (c) Solsort field greensand and (d) Berea sandstone at 20 MHz obtained at temperatures ranging from 10 to 70°C.

References

[1] Dunn, K., Bergman, D.J., and LaTorraca, G.A., 2002, Nuclear Magnetic Resonance-Petrophysical and Logging Applications. New York: Handbook of Geophysical Exploration: Seismic Exploration, Pergamon Press.