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Permeability prediction by NMR and SIP – a laboratory study

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We present the results of NMR (Nuclear Magnetic Resonance) and SIP (Spectral Induced Polarization) measurements on sandstone and limestone samples, gathered within a diploma thesis. From the SIP and NMR results we calculated porosities and permeabilities using empirical relations proposed in the literature and compared these calculated values with independent poro-perm measurements. The study was carried out to verify the applied empirical relations.

The NMR method is most sensitive to hydrogen atoms. NMR relaxation measurements on rock samples and in boreholes are used for a fast and non-destructive determination of porosity, pore-size distribution, and prediction of permeability. The SIP method records the frequency dependent complex resistivity. Whereas resistivity mainly depends on water content and salinity, the frequency dependence is strongly influenced by the inner rock structure. For NMR measurements, the calculated and measured porosities agree. The permeabilities calculated from NMR agree reasonably well with the measured permeabilities. Only for limestones with porosities less than 8 percent the applied relation (Kenyon equation) fails to predict the permeability. For SIP measurements, neither the relation between the imaginary electrical conductivity and permeability (Börner et al., 1996) nor the relation between relaxation time (of the Cole-Cole Model) and permeability (Binley et al., 2005) could be confirmed by our data.

Both, SIP and NMR, follow directly from the microscopic pore structure and the physico-chemical properties of the inner surfaces. Deducing the permeability from

either method alone requires assumptions about the inner surface properties. We study whether a combination of SIP and NMR enables the prediction of the permeability independent of initial assumptions.