Time-dependent Diffusion Coefficients in Sedimentary Rocks Predicted by a Fractal Capillary Model

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ABSTRACT

Applying the pulsed field-gradient nuclear magnetic resonance (PFG-NMR) technique, time-dependent self-diffusion coefficients, $D(\Delta)$, of water were measured in anhydrite cemented sandstones, in order to determine geometrical parameters of the pore space. As a first approach the Padé approximation, combining the short-time behaviour with the long-time asymptotic value of $D(\Delta)/D_0$ (where D_0 is the bulk diffusion coefficient), was applied for determining the surface-to-pore volume ratio, S/V_{por}, and the tortuosity, T. As this theoretical approach is based on interpolation, we tried to simulate the time dependence of $D(\Delta)$ based on physical principles and pore space models. This novel approach was compared with the Padé approximation and tested with data from the literature. For porous media with low tortuosity values and simple geometry such as a packing of glass beads, both methods are in good accordance and give similar results. In sedimentary rocks, however, the new method of calculation is able to deliver more details of pore geometry. However, its main advantage occurs in porous media with fractal geometry or with constricted pores, where the $D(\Delta)/D_0$ curves deviate from the characteristic shape which is e.g. found for packed glass beads.

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