20 μm/s, which was a reasonable value in sandstone. For the distribution in the T_2 range from 0.1 s to smaller value, the distribution deviates more from the dashed line with decreasing of T_2 value, which may be caused by the existence of strong paramagnetic materials (clay for example), leading to the extreme large surface relaxivity in smaller pores.

The surface relaxivities of this rock sample were evaluated using the $Padé$ approximation in 2D D-T_2 correlation map [6]. The surface relaxivities ρ_2 from this method were estimated to be 25 μm/s, which was slightly overestimated in sandstone. This is probably caused by the overestimation of D_a due to the significant internal gradient effect during the diffusion encoding time.

5 Conclusion

The method of using high eigenmode of spin diffusion equation to determine the pore length scales of rock samples has been proved feasible at 2 MHz Rock Core Analyzer. The pore length scales determined at 2 MHz were comparable and confirmed with the distributions from 64 MHz high field. Moreover, the surface relaxivity of rock sample has been estimated from the 2D eigenmode correlation experiment. The results were compared and validated by the results from $Padé$ diffusion-relaxation correlation experiment.

Acknowledgements

The project was supported by the New Zealand Ministry of Business, Innovation, and Employment via the Grant "New NMR Technologies". H-B. Liu thanks the financial supports from Chinese Scholarship Council (CSC) and the technical supports from Magritek Ltd.

References

[1] Y.-Q. Song, Using internal magnetic fields to obtain pore size distributions of porous media, Concepts in Magnetic Resonance 18A (2) (2003) 97–110.

[2] Y.-Q. Song, S. Ryu, P. Sen, Determining multiple length scales in rocks, Nature 407 (2000) 178–181.

[3] S. Muncaci, I. Ardelean, The Influence of the Magnetic Impurity Content on the Pore Size Distribution Determination via the DDIF Technique, Applied Magnetic Resonance 44 (3) (2012) 365–373.

[4] E. E. Sigmund, H. Cho, Y.-Q. Song, High-resolution MRI of internal field diffusion-weighting in trabecular bone., NMR in Biomedicine 22 (4) (2009) 436–448.

[5] N. V. Lisitza, W. S. Warren, Y.-Q. Song, Study of diffusion in erythrocyte suspension using internal magnetic field inhomogeneity., Journal of Magnetic Resonance 187 (1) (2007) 146–154.

[6] L. Zielinski, R. Ramamoorthy, C. Minh, K. Daghar, R. Sayed, Restricted Diffusion Effects in Saturation Estimates from 2D Diffusion-Relaxation NMR Maps, SPE Annual Technical Conference and Exhibition (2010) 1–8.

[7] K. Brownstein, C. Tarr, Importance of classical diffusion in NMR studies of water in biological cells, Physical Review A 19 (1979) 2446–2453.

[8] Y.-Q. Song, Detection of the high eigenmodes of spin diffusion in porous media, Physical Review Letters 85 (18) (2000) 3878–3881.

[9] N. V. Lisitza, Y.-Q. Song, The behavior of diffusion eigenmodes in the presence of internal magnetic field in porous media, The Journal of Chemical Physics 114 (20) (2001) 9120.

[10] L. Venkataramanan, Y.-Q. Song, M. D. Hürlimann, Solving Fredholm Integrals of the First Kind With Tensor Product Structure in 2 and 2.5 Dimensions, IEEE Transactions on Signal Processing 50 (5) (2002) 1017–1026.

© 2014,HuabingLiu