Contribution ID: **646**

Type: **Oral Presentation**

Magnetic Resonance and Magnetic Resonance Imaging of Porous Media –Recent Developments

Monday, 31 May 2021 15:55 (15 minutes)

Magnetic resonance presents an array of unparalleled opportunities in probing fluids in porous media. Magnetic resonance methods are nowadays routinely employed in well-logging, monitoring underground water resources, laboratory analysis, and industrial process and quality control. Despite these widespread applications, there are significant problems associated with the inability of traditional magnetic resonance methods in observing short-lived signals typically observed in porous media. The University of New Brunswick (UNB) MRI Research Centre developed new methodologies to address these shortcomings and consolidated magnetic resonance imaging (MRI) as an excellent tool for in situ studies of a wide variety of materials, including rocks, sediments, wood, concrete, composites, foods, and microporous materials.

Innovations of UNB MRI Research Centre exploit (1) free induction decay as a means of signal formation for detecting short-lived signals, (2) low magnetic field intensities to reduce the effects of magnetic susceptibility difference of matrix/fluids, (3) pure phase encoding to avoid artefacts arising from susceptibility effects, chemical shift, B0 inhomogeneity and linewidth restriction on resolution, (4) the importance of information in the proximity of k-space origin on the quantitative quality of data, (5) non-magnetic metallic environmental sample holders with integrated radiofrequency probes, and (6) correcting gradient waveforms or their effect. These innovations permitted quantitative and in vivo imaging of a variety of processes by a combination of specialized software and hardware. Several new discoveries and some interesting observations relevant to porous media applications were facilitated by these developments in the past few years:

(A) Magnetic resonance methods directly measured gas pressure in microscale pores of methane gas hydrates in a pioneering work. In a methane hydrate-bearing sand pack with 2.8% residual water at 2 MPa and 4℃, the elevated pore gas pressure was measured to be 59 MPa. (B) New models proposed for magnetic resonance relaxation in multicomponent mixtures in porous media were matched to experimental data on CO2/decane mixtures in Berea sandstone at 40℃ and 6 MPa and 9 MPa, for miscible and immiscible conditions, respectively. The density of decane in the pore-surface bound layer decreased during the miscible drainage of decane by CO2. In contrast, in immiscible displacement of decane by CO2, the pore-surface area wetted by decane monotonically decreased only at saturations smaller than the residual saturation –consistent with the development of noncontinuous wetting films on the pore surface. (C) We established that nonground eigenvalues of the diffusion-relaxation equation indeed contribute to the magnetic resonance relaxation signal of common porous media, contrary to common belief. This discovery permits direct pore size estimation from common T1 and T2 distribution measurements. (D) The new T1-T*2 method proposed as a 2D relaxation correlation experiment permits the detection of mobile and immobile 1H in porous materials, especially in shales and concrete material with significant susceptibility effects.

The recent addition of a variable-field superconducting magnet to the UNB MRI Research Centre is expected to further help the development of new methods and applications in porous media.

Time Block Preference

Time Block B (14:00-17:00 CET)

References

https://doi.org/10.1016/j.marpetgeo.2020.104296
https://doi.org/10.1103/PhysRevApplied.11.041002
https://doi.org/10.1051/e3sconf/20198902005
https://doi.org/10.1051/e3sconf/20198902008
https://doi.org/10.2118/189458-PA
https://doi.org/10.2118/186089-PA
https://doi.org/10.1063/1.5013031

Acceptance of Terms and Conditions

Click here to agree

Newsletter

Student Poster Award

Primary authors: Dr AFROUGH, Armin (University of New Brunswick; Center for Oil and Gas - DTU, Technical University of Denmark); Prof. BALCOM, Bruce J. (University of New Brunswick)

Presenter: Dr AFROUGH, Armin (University of New Brunswick; Center for Oil and Gas - DTU, Technical University of Denmark)

Session Classification: MS10

Track Classification: (MS10) Advances in imaging porous media: techniques, software and case studies