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Novel Micro-Scale Fluid Saturation Method through Conjoint Conjunction Coupling of MRI & Micro-CT Images

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A knowledge of fluid saturation at any one cross-section is very often required when studying fluid behaviour in porous media. It becomes more challenging in case of micro-scale geometry with heterogeneous morphology, as in complex geological samples. Our research effort in solving the challenge has led to a novel solution. We named this new saturation measurement identification approach, Micro-CT (uCT) and MRI (Magnetic Resonance Imaging) Coupling and Analysis (MIMICAN). This method couples the imaging information from MRI of 600-micron image resolution and uCT of 40-micron image resolution. Through conjoint (Haas O. M. R. - 2017) conjunction image analysis is used to produce multi-layer multi–micro-scale convergence. MIMICAN starts by aligning uCT and MRI images orientation and image slices location. Then we analysed uCT images using advanced 3D imaging software module "Interactive 3D"(ImageJ - 1.51p). Also, we analyse MRI image contrast to split high and low fluid contents effects on MRI signal. As a result, we accomplished a breakthrough two ways resolution up-scale and downscale between uCT and MRI. We find that MRI has detected fluid distribution within the micro-scale heterogeneous rock morphology. This MRI detection is in correspondence with uCT rock images at similar cross-sectional locations. MRI fluid image contrast gives the dynamic explanation to the static property of rock pore network. This coupling results in indexing fluid saturation measurement spatially at a micro scale. The up-scaled uCT images manage to enhance the lower MRI images resolution (600 um). Aided, down-scaled MRI images with uCT produces high-resolution fluid saturation measurement reaching to uCT (40 um) resolution. By uCT image processing for localized porosity values, we can then determine permeability using Permeability Active Searching (Al-Farisi, O. - 2004) or a Hybrid Predictor (Teklu, T. W. - 2010) to estimate fluid flow behaviour in micro-scale. This method can enrich the understanding of fluid flow for a wide range of a significant amount of image and sample data. In this research, we infer that current saturation measurement methods that focus on bulk fluid saturation cannot explain the fluid flow behaviour in solids internal micro-scale pore network. Therefore, to solve deficiency, we used the latest advancement in uCT and MRI imaging in enabling higher resolution of pore network saturation measurement. We also recommend further research in more refinement of uCT image up-scaling for enriching MRI image saturation measurement which paves the way towards micro-scale wettability (Li, H. - 2015) determination and alteration mechanism physical model (Makaremi, M. - 2016). Also, MRI Images resolution enhancement is achievable (600 to 250 um) with 3 Tesla (Knäblein, J. - 2013) MRI Machine. Finally, for efficiently using MIMICAN, a Robotic Process Automation (RPA) code is essential to speed the analysis.

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Primary author: Mr AL-FRAISI, Omar (Khalifa University of Science and Technology)

Co-authors: Dr RAZA, Aikifa (Khalifa University of Science and Technology); Mr ZHANG, HongTao (Khalifa University of Science and Technology); Dr ZHANG, TieJun (Khalifa University of Science and Technology)

Presenter: Mr AL-FRAISI, Omar (Khalifa University of Science and Technology)

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