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***Fast swelling effect of light oil under reservoir conditions: Micro-CT and Pressure-decay experiments***

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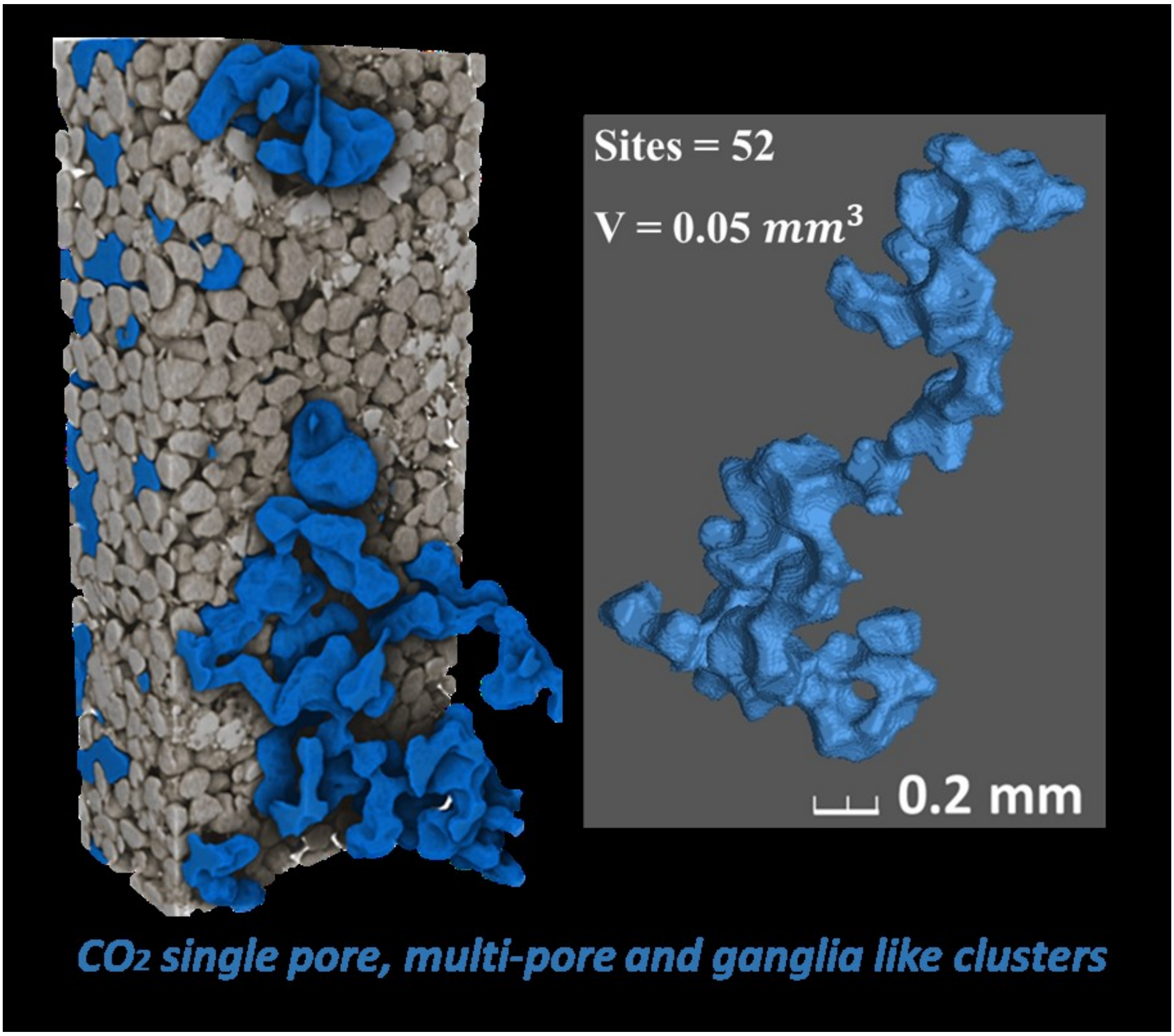
$CO_2$ injection into geological formations, mainly depleted gas/oil reservoirs and deep saline aquifers, is considered as a promising technique for enhanced oil recovery (EOR) and $CO_2$ sequestration [1,2]. The fundamental for technological applications is a *scale-dependent* process, involving an understanding of the pressure and temperature dependence on key physico-chemical properties, such as volume increase, miscibility, solubility, diffusion, and interfacial tension and their complex correlations. To the best of our knowledge, this is the first systematic study conducted to investigate the volume increase in the $CO_2$-decane system at elevated pressures corresponding to the subsurface pressure conditions encountered in reservoirs using combined micro-CT - and pressure-decay experiments.
We developed a conceptual model which considers *$CO_2$ density fluctuations* near the critical range, and consistently explain the time dependence of the volume increase for the respective thermodynamic state. Our experimental results verify this conceptual model, that volume swelling in the *non-critical pressure range* (< 6 MPa) is a surface effect with limited penetration depth. The fast $CO_2$ mass transfer between gas phase and oil phase is a *non-equilibrium* process and has to be described by a *non-equilibrium* model. Our non-equilibrium model shows strong agreement with the experimental results presented in this study. However, the volume increases in the *critical pressure range* (6 – 7.5 MPa) is caused by mixing of liquid $CO_2$ droplets and the oil phase, i.e. to a level increase of the liquid mixed phase and the experimental contact angle validates it. Moreover, our experimental findings show a reduction in the oil swelling as the temperature increases from 20°C to 30°C (at constant pressure). We derive the minimum miscibility pressure (MMP) of the $CO_2$-decane system by evaluating the difference in the intensity values [3] for each phase (using micro-CT) as pressure increases at 20°C and 30°C [3]. The MMP is 5.9 MPa and 6.9 MPa at 20°C and 30°C, respectively. From a broader perspective, our comprehensive study of oil swelling due to $CO_2$ injection has profound relevance in optimizing $CO_2$-EOR projects.




CO2 trapped clusters in porous media, visualized by Micro-CT imaging

[1] Hill. B, Hovorka S, Melzer S. 2013. Geologic carbon storage through enhanced oil recovery. *Energy Procedia, 37:6808-6830*.
[2] Rezk, M. G., & Foroozesh, J. (2019). Phase behavior and fluid interactions of a CO2-Light oil system at high pressures and temperatures. *Heliyon*, *5*(7).
[3] Liu, Y., Jiang, L., Tang, L., Song, Y., Zhao, J., Zhang, Y., ... & Yang, M. (2015). Minimum miscibility pressure estimation for a CO 2/n-decane system in porous media by X-ray CT. *Experiments in Fluids*, *56*, 1-9.