Contribution ID: **1000** Type: **Oral Presentation**

Ostwald Ripening Investigation using 3D Micro-CT Imaging

Monday, 22 May 2023 11:05 (15 minutes)

The goal of reducing carbon emissions relies heavily on the world's energy sectors to undergo significant energy transformations. The hydrogen economy plays a critical role in achieving that goal by harvesting hydrogen and using it as an energy carrier. The current storage options limit hydrogen's large-scale adaptation to a major energy form. For that reason, underground hydrogen storage has been an alternative that appealed to the scientific community and prompted multiple studies to explore its feasibility in several aspects. One of those aspects is evaluating the potential of remobilising trapped gases in a porous medium through the Ostwald ripening phenomenon. As such, we examined the phenomenon of Ostwald ripening by leaving the H2-brine system in a sandstone sample uninterrupted for 12 hours to observe any hydrogen re-distribution. The sample was scanned with a micro-CT twice: before and after. Additionally, we demonstrated the derivation of a simple equation that estimates the timescale for disconnected gas ganglia to reach partial equilibrium over a given length scale. Finally, we explored whether changes in the interfacial curvature, in-situ contact angles, saturation distribution, and gas ganglia size distribution occurred during the 12 hours.

We observed the re-distribution of gas ganglia and the emergence of multiple larger new gas ganglia with a maximum extent of about 2 mm. This confirmed the length scale estimation made by the derived equilibrium timescale equation. Additionally, a slight increase in curvature was observed after 12 hours, and the mean contact angle slightly increased at the bottom part of the sample. Overall, our experimental study of the Ostwald ripening phenomenon presented significant remobilisation of trapped gas ganglia and gas re-distribution at the pore scale, which could mean that residually trapped hydrogen can be less than what is thought.

Participation

In-Person

References

AlRatrout, A., Raeini, A.Q., Bijeljic, B. and Blunt, M.J., 2017. Automatic measurement of contact angle in pore-space images. Advances in Water Resources, 109, pp.158-169.

Andrew, M., Bijeljic, B. and Blunt, M.J., 2014. Pore-scale contact angle measurements at reservoir conditions using X-ray microtomography. Advances in Water resources, 68, pp.24-31.

Chabab, S., Theveneau, P., Coquelet, C., Corvisier, J. and Paricaud, P., 2020. Measurements and predictive models of high-pressure H2 solubility in brine (H2O+ NaCl) for underground hydrogen storage application. International Journal of Hydrogen Energy, 45(56), pp.32206-32220.

De Chalendar, J.A., Garing, C. and Benson, S.M., 2018. Pore-scale modelling of Ostwald ripening. Journal of Fluid Mechanics, 835, pp.363-392.

Garing, C., de Chalendar, J.A., Voltolini, M., Ajo-Franklin, J.B. and Benson, S.M., 2017, June. Pore-scale capillary pressure analysis using multi-scale X-ray micromotography. Advances in Water Resources, 104, pp.223-241.

Garing, C., de Chalendar, J.A., Voltolini, M., Ajo-Franklin, J.B. and Benson, S.M., 2017, November. Pore-scale investigations into the stability of residual CO 2. In APS Division of Fluid Dynamics Meeting Abstracts (pp. G35-006).

Hashemi, L., Glerum, W., Farajzadeh, R. and Hajibeygi, H., 2021. Contact angle measurement for hydrogen/brine/sandstone system using captive-bubble method relevant for underground hydrogen storage. Advances in Water Resources, 154, p.103964.

Higgs, S., Da Wang, Y., Sun, C., Ennis-King, J., Jackson, S.J., Armstrong, R.T. and Mostaghimi, P., 2022. In-situ hydrogen wettability characterisation for underground hydrogen storage. International Journal of Hydrogen Energy, 47(26), pp.13062-13075.

Hosseini, M., Fahimpour, J., Ali, M., Keshavarz, A. and Iglauer, S., 2022. H2– brine interfacial tension as a function of salinity, temperature, and pressure; implications for hydrogen geo-storage. Journal of Petroleum Science and Engineering, 213, p.110441.

Iglauer, S., Ali, M. and Keshavarz, A., 2021. Hydrogen wettability of sandstone reservoirs: implications for hydrogen geo-storage. Geophysical Research Letters, 48(3), p.e2020GL090814.

Jha, N.K., Al-Yaseri, A., Ghasemi, M., Al-Bayati, D., Lebedev, M. and Sarmadivaleh, M., 2021. Pore scale investigation of hydrogen injection in sandstone via X-ray micro-tomography. International Journal of Hydrogen Energy, 46(70), pp.34822-34829.

Ostwald, W., 1900. Über die vermeintliche Isomerie des roten und gelben Quecksilberoxyds und die Oberflächenspannung fester Körper. Zeitschrift für physikalische Chemie, 34(1), pp.495-503.

Xu, R., Li, R., Huang, F. and Jiang, P., 2017. Pore-scale visualization on a depressurization-induced CO2 exsolution. Science Bulletin, 62(11), pp.795-803.

Xu, K., Mehmani, Y., Shang, L. and Xiong, Q., 2019. Gravity-induced bubble ripening in porous media and its impact on capillary trapping stability. Geophysical Research Letters, 46(23), pp.13804-13813.

MDPI Energies Student Poster Award

Yes, I would like to submit this presentation into the student poster award.

Country

United Kingdom

Acceptance of the Terms & Conditions

Click here to agree

Energy Transition Focused Abstracts

This abstract is related to Energy Transition

Primary authors: Mr DOKHON, Waleed (Imperial College of London); Prof. ZHANG, Yihuai (University of Glasgow); BLUNT, Martin (Imperial College London); BIJELJIC, Branko (Imperial College)

Presenter: Mr DOKHON, Waleed (Imperial College of London)

Session Classification: MS01

Track Classification: (MS01) Porous Media for a Green World: Energy & Climate