

26th Anniversary of the Imperial College Consortium on Pore-Scale Modelling and Imaging

Yearly progress report

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Executive Summary

This is the annual report of the Imperial College Consortium on Pore-Scale Modelling and Imaging. At our project meeting we will highlight the progress we have made over the last year as well as presenting plans for the future.

We have maintained a large group of 20 researchers this year, with an overall theme of flow in porous media in the energy transition. The major highlight for us in the lab was the delivery of a new micro-CT scanner: our old Zeiss Versa and Heliscan instruments have served us well for over 7 years, but were no longer working reliably. We now have an EasyTom from RX solutions, based in France. So far things are working well with a simpler arrangement for reservoir condition experiments. This was paid for centrally by Imperial, recognising the importance of maintaining our experimental facilities to support excellent research. However, the installation was not completed without some problems. Like cars and waistlines, CT scanners seem to be getting bigger. It's a *micro*-CT for goodness sake, but every time we measured the size of this whale of an instrument, it seemed to get bigger. Now, neither our lab space nor the professor in charge are getting any larger: fortunately with the removal of a wall and some rearrangement of the electricity supply our new jumbo so-called-micro scanner has squeezed its way into the limited space we have available.

On a personal note, in 2025 I was elected an International Member of the US Academy of Engineering. Unfortunately I missed the inauguration ceremony but hope to be able to attend in October 2026. I was also part of the President's International Fellowship Initiative, run by the Chinese Academy of Sciences: I visited China twice in 2025, with one highlight (other than seeing dozens of pandas) being part of a seminar that had over 10,000 participants online – and that was on a Sunday afternoon. Evidently there are many people keen to hear the latest in porous media research! As ever this is a reflection of the hard work and creativity of the many students, post-docs and other colleagues we have worked with over the years, and a recognition of the global reach of our research.

There has been several changes in our group over the last year as our post-docs develop their careers and our PhD students graduate. Sajjad Foroughi, who for many years had led our modelling activities, left us last year to take up a position in industry. Asli Gundogar finished her research with us on generalized pore-network modelling and now has a faculty position at the Middle Eastern Technical University in Turkey. Anin Patmonoaji who worked with Asli on the measurement of multiphase flow properties in complex rocks is now a post-doc at University College London. Our Chinese visitors Shanlin Ye and Menglu Kang left last year, but we welcomed two new visitors: Rui Zhang and Jinlei Wang. Rui is working on applications of machine learning to flow in porous media problems, from drilling to image segmentation. Jinlei's research is on simulations of reactive transport in porous media. We celebrated the graduation of three of our PhD students. Sepi Goodarzi, who had pioneered our work in hydrogen storage, is now a post-doc in our Department of Materials, looking at nutrient uptake through soils into roots – using micro-CT scanning to image the transport of nanoparticles. Abdulaziz Alsaleh who worked on thermal degradation in polymer flooding passed his viva late last year. Hussain Alzahrani who worked on surfactant flooding also passed his viva last month. Both Abdulaziz and Hussain will be returning to work for Saudi Aramco.

We have welcomed two new PhD students under the Resource Geophysics Academy funded by Sinopec: Zhi Zheng, who will work on three-phase flow in porous media, and Yuxin Cheng who will continue our research on reactive transport during multiphase flow.

We no longer prepare a separate written report. As a matter of routine practice, we now make all our publications – with associated codes and data – open access. Rather than collate some papers, I will simply provide the DOI links to all our recent work: in this way you can read whatever interests you from the considerable body of material that we have published in 2025 – indeed this is a record year in terms of the number of papers published.

Of course, we have many more results and ideas to present; these will be discussed at the meeting itself.

The current researchers in the group are:

Martin Blunt, Professor of Flow in Porous Media – overall supervision and theories of multiphase flow in porous media

Branko Bijeljic, Principal Research Fellow – multiphase flow and reactive transport

Rukuan Chai, Post-doctoral researcher – imaging and analysis of carbon dioxide storage

Linqi Zhu, Post-doctoral researcher – machine learning and time-resolved images

Hussein Alzahrani, completed PhD student – surfactant flooding

Ademola Adebimpe, 4th year PhD student – pore-scale modelling of Ostwald ripening

Jack Ma, 4th year PhD student – application of machine learning to pore-scale modelling

Waleed Dokhon, 3rd year PhD student – experimental studies of hydrogen storage

Ahmed Alzaabi, 3rd year PhD student – comparison of nitrogen, carbon dioxide and hydrogen storage

Anfal Al Zarafi, 3rd year PhD student – carbon dioxide storage in reservoir carbonates

Olatunbosun Adedipe, 3rd year PhD student – reactive transport and cement dissolution

Ibrahim Alobaidan, 3rd year PhD student – modelling and design of hydrogen storage

Qianqian Ma, 3rd year PhD student – experimental studies of reactive transport

Yuxi Liang, 3rd year PhD student – pore-scale modelling of salt precipitation

Sasha Karabasova, 2nd year PhD student – pore-scale modelling of rate effects

Mohammed Bello, 2nd year PhD student – wettability effects in gas storage

Oranan Ariyarat, 2nd year PhD student – carbon dioxide storage in depleted oilfields

Zhi Zheng, 1st year PhD student – three-phase flow in porous media

Yuxin Cheng, 1st year PhD student – reactive transport in multiphase flow

Rui Zhang, visiting PhD student – applications of machine learning

Jinlei Wang, visiting PhD student – simulations of reactive transport

Also a collaboration with Zhejiang University in China:

Qingyang (Lewis) Lin, Professor, Zhejiang University, China – multiphase flow

Mingliang Qu, 4th year PhD student Zhejiang University, China – multiphysics modelling

All our publications, theses, reports and presentations are available on our website:

<https://www.imperial.ac.uk/earth-science/research/research-groups/pore-scale-modelling/>

We also have a Github site where we have placed all our codes:

<https://github.com/ImperialCollegeLondon/porescale>

Project publications in 2025 with web links

1. A A Alsaleh, A H Muggeridge, and M J Blunt, "Why gravity improves waterflood recovery in oil-wet and mixed-wet reservoirs," *Geoenergy Science and Engineering*, **243**, 213375, <https://doi.org/10.1016/j.geoen.2024.213375> (2024).
2. Y-F Zhang, M-L Qu, J-P Yang, S Foroughi, B Niu, Z-T Yu, X Gao, M J Blunt, and Q Lin, "Prediction of CO₂ storage efficiency and its uncertainty using deep-convolutional GANs and pore network modelling," *Applied Energy*, **381**, 125142. <https://doi.org/10.1016/j.apenergy.2024.125142> (2025).
3. A AlZaabi, H M Alzahrani, A Alhosani, B Bijeljic, and M J Blunt, "Wettability, pore occupancy, connectivity and Ostwald ripening of nitrogen, carbon dioxide and hydrogen in carbonate rocks: A comparative study," *International Journal of Hydrogen Energy*, **135**, 596-608 <https://doi.org/10.1016/j.ijhydene.2024.04.399> (2025).
4. S Mao, S Yu, J Xu, H Chen, W Zhao, M J Blunt, Q Kang, M Gross, B Chen, J Van Wijk, Q Yuan, K Gao, S R Kazi, and M Mehana, "Geologic hydrogen: a review of resource potential, subsurface dynamics, exploration, production, transportation, and research opportunities," *Energy & Environmental Science*, **18**, 9991-10035 <https://doi.org/10.1039/D5EE02910D> (2025).
5. S Wang, A P Constantinou, G Zhang, Y Zhang, M J Shojaei, B Zhou, D L Jones, T Roose, M J Blunt, T K Georgiou, and I E Dunlop, "A micelle-templated nanoparticle contrast agent enables dynamic microscale X-ray computed tomography imaging of the soil aqueous phase," *RSC Applied Polymers*, **3**, 1596-1612 <https://doi.org/10.1039/D5LP00072F> (2025).
6. R Chai, Q Ma, S Goodarzi, F Y Yow, B Bijeljic, and M J Blunt, "Multiphase Reactive Flow During CO₂ Storage in Sandstone," *Engineering*, **48**, 81-91 <https://doi.org/10.1016/j.eng.2025.01.016> (2025).
7. S Foroughi, M J Shojaei, N Lane, B Rashid, D Lakshtanov, Y Ning, Y Zapata, B Bijeljic, and M J Blunt, "A Framework for Multiphase Pore-Scale Modeling Based on Micro-CT Imaging," *Transport in Porous Media*, **152**, 18 <https://doi.org/10.1007/s11242-025-02156-6> (2025).
8. L Zhu, B Bijeljic, and M J Blunt, "Diffusion Model-Based Generation of Three-Dimensional Multiphase Pore-Scale Images," *Transport in Porous Media*, **152**, 22 <https://doi.org/10.1007/s11242-025-02158-4> (2025).
9. S Ye, X Song, Z Ma, G Yang, L Zhou, M Zhou, L Xiao, G Wen, B Bijeljic, and M J Blunt, "A noise-resistant and annotation-free supervoxel-based algorithm for rapid segmentation of multiphase X-ray images," *Advances in Geo-Energy Research*, **16**, 50–59 <https://doi.org/10.46690/ager.2025.04.06> (2025).
10. S Goodarzi, G Zhang, B Bijeljic, and M J Blunt, "Ostwald ripening leads to less hysteresis during hydrogen injection and withdrawal: A pore-scale imaging study," *International Journal of Hydrogen Energy*, **31**, 475-485 <https://doi.org/10.1016/j.ijhydene.2025.02.066> (2025).
11. G Luo, B Bijeljic, S Luo, L Xiao, R Shao, and M J Blunt, "A Lightweight Multi-scale Neural Network for Inversion of NMR Relaxation Measurements in Porous Media," *Transport in Porous Media*, **152**, 28 <https://doi.org/10.1007/s11242-025-02164-6> (2025).
12. Y Wang, M Bortolotto, S Suo, C O'Sullivan, M J Blunt, and M Sawada, "Pore Scale Study of Polymer Fluid Flow," *IOP Conference Series: Earth and Environmental Sciences*, **1480**, 012115 <https://doi.org/10.1088/1755-1315/1480/1/012114> (2025).

13. F Aljaberi, H Belhaj, M Al Kobaisi, and M J Blunt, "Direct Measurement of Pore-Scale Contact Angle and Curvature from Grayscale Micro-CT Images," SPE-224625-MS, Proceedings of the GOTECH, Dubai City, UAE, April <https://doi.org/10.2118/224625-MS> (2025).
14. M AlZahrani, B Bijeljic, S Foroughi, and M J Blunt, "Pore-scale imaging and analysis of secondary surfactant flooding in a heterogeneous carbonate rock," *Geoenergy Science and Engineering*, **248**, 213728 <https://doi.org/10.1016/j.geoen.2025.213728> (2025).
15. A Patmonoaji, R Chai, A S Gundogar, M Regaieg, M J Blunt and B Bijeljic, "Differential Imaging-Based Porous Plate Measurements of Fluid Distribution and Capillary Pressure During Drainage in a Multiscale Oolitic Limestone," *Transport in Porous Media*, **152**, 34 <https://doi.org/10.1007/s11242-025-02171-7> (2025).
16. S Suo, S Foroughi, M J Blunt, and C O'Sullivan, "Pore-network modeling of polymer flow in porous media," *Computers and Geotechnics*, **182**, 107142 <https://doi.org/10.1016/j.compgeo.2025.107142> (2025).
17. A. Alobaidan, B Bijeljic, and M J Blunt, "Drive mechanisms and hydrogen recovery in underground storage: a material balance and simulation approach," *International Journal of Hydrogen Energy*, **146**, 149891 <https://doi.org/10.1016/j.ijhydene.2025.06.081> (2025).
18. A A Aboulrous, N M Darraj, V Cunsolo, D Uko, J P M Trusler, and M J Blunt, "Effect of imidazolium-based ionic liquid on CO₂ sequestration: a study on solubility, interfacial properties, and X-ray imaging in water-wet formations," *Journal of Molecular Liquids*, **435**, 128111 <https://doi.org/10.1016/j.molliq.2025.128111> (2025).
19. S Mahmoudvand, K S Sorbie, A Skauge, and M J Blunt, "Modelling Pore Occupancies in Three-phase Displacements from Micro-CT Images Using a Physics-Based Theory of Wettability and Miscibility Conditions," *Transport in Porous Media*, **152**, 71 <https://doi.org/10.1007/s11242-025-02208-x> (2025).
20. Z Ma, B Bijeljic, G Wen, K Tang, Y Wang, and M J Blunt, "Super-Resolution Imaging of Multiphase Fluid Distributions in Porous Media Using Deep Learning," *Transport in Porous Media*, **152**, 85 <https://doi.org/10.1007/s11242-025-02210-3> (2025).
21. A J Amabogha, A Taghavinejad, W Dokhon, S Marathe, L Ma, B Bijeljic, M Blunt, M Arif, and Y Zhang, "Temporal Dynamics of Reactive CO₂ Flow in Carbonate Rock: Insights from 4D Synchrotron Imaging," *Energy & Fuels*, **39**, 20397–20409 <https://doi.org/10.1021/acs.energyfuels.5c02297> (2025).
22. R Zhang, X Song, S Ye, Z Zhu Y Wi, B Li, H Liu, B Bijeljic, and M J Blunt, "Real-Time Bit Performance Monitoring: A Dual-Dimensional Graph Attention Network with Multivariate Time-Series Data," SPE-227965-MS, proceedings of the SPE Annual Technical Conference and Exhibition, Houston, Texas, USA, October. <https://doi.org/10.2118/227965-MS> (2025).
23. H M AlZahrani, B Bijeljic, R Chai, and M J Blunt, "Pore-Scale Analysis and Visualization of Tertiary Cationic Surfactant Flooding in a Complex Carbonate," *ACS Omega*, **10**, 51383–51395 <https://doi.org/10.1021/acsomega.5c06863> (2025).
24. Y Wang, S Suo, M S Bortolotto, C O'Sullivan, and M J Blunt, "Particle-Scale Simulation of Polymer Fluid Permeation in Sand," *International Journal of Geomechanics*, **25**, 11736 <https://doi.org/10.1061/IJGNAL.GMENG-11736> (2025).
25. M-L. Qu, Z-B Ding, D Zhang, S Foroughi, H Chen, Z-T Yu, J Zhang, L Xiao, M J Blunt, X Fan, and Q Lin "A Machine Learning-Driven Pore-Scale Network Model Coupling Reaction Kinetics and Interparticle Transport for Catalytic Process Design." *Advanced Science*, e13649. <https://doi.org/10.1002/advs.202513649> (2025).

26. A Patmonoaaji, A S Gundogar, Q Ma, M Regaieg, M J Blunt, and B Bijeljic, "Spontaneous Imbibition and Forced Water Injection in Mixed-Wet Multiscale Oolitic Limestone Studied Through the Differential Imaging-Based Porous Plate Technique," *Transport in Porous Media*, **152**, 110 <https://doi.org/10.1007/s11242-025-02248-3> (2025).
27. R Chai, S Foroughi S Goodarzi, A Patmonoaaji, F Y Yow, B Bijeljic, and M J Blunt, "Pore-Scale Imaging to Quantify the Evolution and Reduction in Trapped CO₂ due to Ostwald Ripening," *Environmental Science & Technology*, **59**, 26419–26427 <https://doi.org/10.1021/acs.est.5c06424> (2025).
28. M Aminzadeh, T Kokate, A U Chaudhry, H Rabbani, B Bijeljic, M J Blunt, and N Shokri, "Microplastic-induced alterations in water flow and solute transport dynamics in soil," *Scientific Reports*, **15**, 42941 <https://doi.org/10.1038/s41598-025-30476-6> (2025).
29. M J Blunt, S Sun, M A Boone, L Zhang, and J Cai, "Digital rock physics and fluid flow in the context of the energy transition," *Advances in Geo-Energy Research*, **18**, 299–302 <https://doi.org/10.46690/ager.2025.12.10> (2025).
30. N Darraj, S Manoorkar, C Spurin, S Foroughi, M Saleh, S Berg, M J Blunt, and S Krevor, "Heterogeneity Driven Trapping at the Pore-Network Scale in Edwards Brown Dolomite," *Energy & Fuels* <https://doi.org/10.1021/acs.energyfuels.5c04544> (2025).
31. S Ahmadpour, R Gholami, M Ghaedi, and M J Blunt, "An experimental study and mathematical formulation for hydrogen diffusion in water," *Scientific Reports*, **15**, 44790 <https://doi.org/10.1038/s41598-025-28427-2> (2025).

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Martin Blunt and Branko Bijeljic, January 2026