Pore-scale Imaging and Analysis of Multiphase Flow in Improved Oil Recovery by X-Ray Tomography

Supervised by Dr. Branko Bijeljic and Prof. Martin Blunt

In recent years there has been a revolution in our understanding of multiphase flow in porous media, with application to improved oil recovery, carbon dioxide stage and groundwater flow. This revolution has been driven by improvements in imaging, analysis and modelling of pore-scale displacement processes. Part of this endeavour is the development of novel experimental and modelling methods for Improved Oil Recovery by waterflooding based on X-ray microtomography. An exemplar waterflood oil recovery study on a reservoir carbonate rock is shown in Figure 1, where remaining oil ganglia were observed to be greatly affected by wettability.

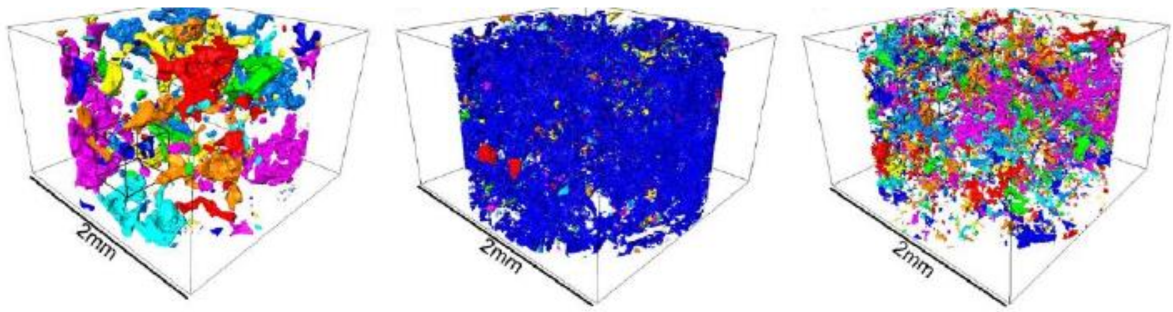

Figure 1 Remaining oil saturation after waterflooding consisting of oil ganglia in different colours in (a) water-wet carbonate; (b) and (c) in mixed-wet carbonate. (from Alhammadi et al., 2017).

Recently, there have been considerable scientific and engineering efforts to explain the origin of this phenomenon and relate it to pore morphology (AlRatrout et al., 2018). Wettability alteration towards decreased water-wetness is the most frequently suggested cause of increased recovery. However, until recently, only indirect wettability measurements at the core scale were possible from which it is not possible to assert which mechanism(s) are responsible for improved recovery.

Advances in X-ray microtomography have made it possible to image the rock and fluids within the pore space at micron resolution and determine contact angles and curvatures at the subsurface reservoirs condition (Andrew et al., 2014). Moreover, state-of-the-art efficient automated methods for the measurement of contact angle and curvature on a pore-by-pore basis have been developed in our group providing ~ 10^6 data points at micron-resolution on *mm*-scale rock cores (AlRatrout et al.,2017; Alhammadi et al., 2017).

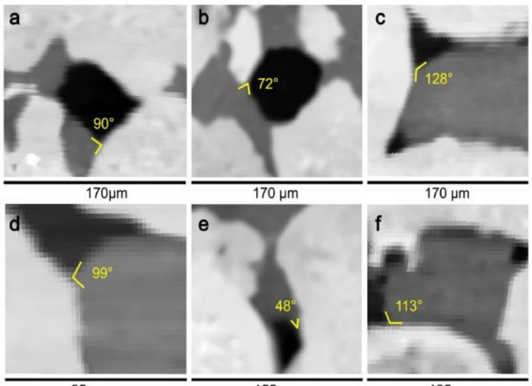

Figure 2 Different wettability states showing the range of contact angles for carbonate/crude oil/brine system. Oil, brine, and rock are shown in black, dark grey and light grey, respectively. From Alhammadi et al. (2017).

In this project you will use these experimental and automated methods on micro-CT images to visualize and analyse wettability states of different injection stages in carbonate rock. Due to complexities in pore morphology, surface roughness and/or mineralogy of a given oil/brine/rock system a wide distribution of contact angle is typically observed (Figure 2).

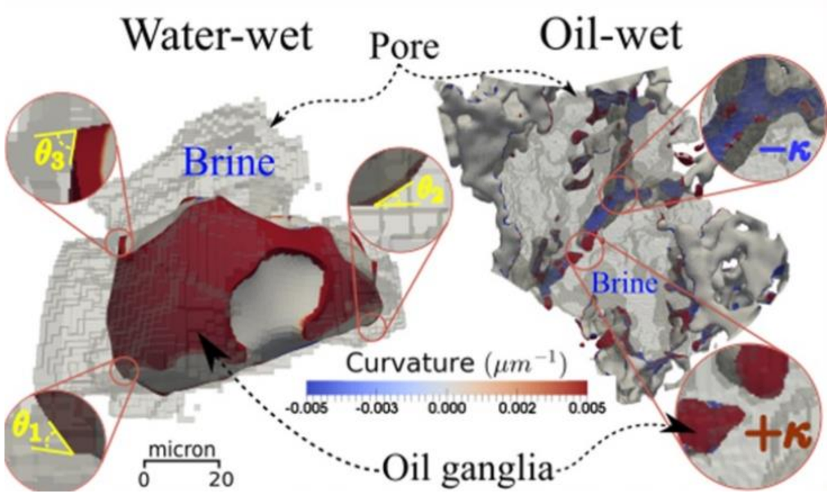

Figure 3 In a water-wet rock, oil is trapped in the form of quasi-spherical ganglia. However, in a mixed-wet rock oil can be retained in layers that follow the pore wall curvature (from AlRatrout et al., 2018).

You are invited to join this cutting-edge research project in digital rocks. You will join a world-leading interdisciplinary team in the Department of Earth Science & Engineering at Imperial College London working on all aspects of oil recovery. Your research will develop novel experimental methodologies to understand oil recovery in the subsurface. In addition to studies by X-ray microtomography at Imperial College, there will be an opportunity to study dynamic imaging experiments at Diamond synchrotron at time resolution of ~10s (Andrew et al, 2015). The successful applicants will be encouraged to publish the research results in internationally recognised peer reviewed journals and present the research results at relevant national and international scientific and professional conferences, and sponsor meetings.

We are looking for students with an outstanding academic record in physical science or engineering including petroleum engineering, physics, chemistry and chemical engineering. The PhD student will have excellent opportunities to collaborate with academia and industry as part of career development.

This studentship is offered through one of the departmental or university scholarships, including the EPSRC and Imperial College Scholarships. For further details about eligibility criteria, please see information at:
http://www.imperial.ac.uk/earth-science/prosp-students/phd-opportunities/

Please do not hesitate to contact us for further information including informal enquires on:

b.bijeljic@imperial.ac.uk +44 207 5946420
m.blunt@imperial.ac.uk +44 207 5946500

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