Optimal Oil Recovery Strategies

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Oil recovery typically proceeds through three phases requiring progressively more technology and greater cost: primary, where reservoir pressure alone drives ($\sim 5\%$ recovery) oil to the surface; secondary, where water flooding is used to both maintain reservoir pressure and sweep oil to a producer well ($\sim 30\%$ recovery); and tertiary, where enhanced processes are required to recover any of the remaining oil. At each step, understanding how one phase displaces another is of major importance to oil-recovery specialists like Schlumberger, as well as for numerous other applications such as CO2 sequestration and ground-water flow, and is a problem where even smallest of improvements can have a dramatic impact.

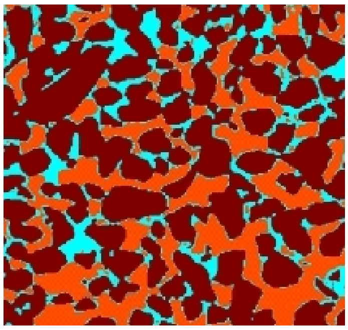

Figure 1: Pore (micro) scale: water-oil (blue-orange) mixture in sandstone (red).

Robust models describing these processes have the advantage of giving information which is impossible to obtain from the field because the dynamic flow occurs deep underground outside the range of possible investigation. Given the daunting complexity of multiphase flow through the pores of a solid (Figure. 1), it is perhaps surprising that certain relationships, such as 'Darcy's Law', successfully describe the macroscale dynamics (Figure. 2), so that industry has been encouraged to support mathematical modelling and simulation as tools that enhance understanding.

This Mini-Project will involve exploring the behaviours of relatively simple mathematical models that give insight into the best strategies of liquid injection into a reservoir to maximise oil recovery. In particular, irreversibility of the formulation and discontinuities in mixture composition, i.e. shock formation, suggest that the time dependence of the pumping may be engineered to have a positive effect on production. Such models are likely to require a numerical solution and can be compared against analytic work conducted in idealised cases[1].

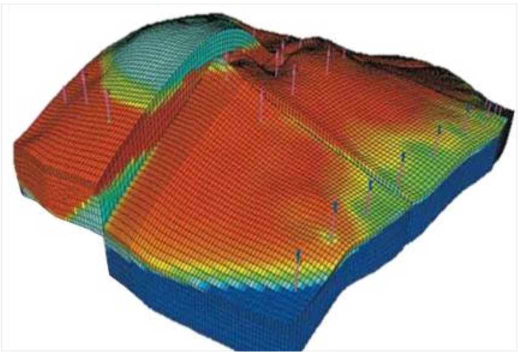

Figure 2: Darcy (macro) scale: simulation of an oilfield using Eclipse software.

A Mini-Project in multiphase flow through porous media would give a flying start to many potential PhD projects, all of which have numerous industrial applications. Depending on the interests of the student, this could involve more complex modelling problems, such as considering more realistic fluids or inhomogenous porous media, or may lead to a more computational route by looking to improve on, or contribute to, the current industry standard of software, see[2].

Schlumberger is an oilfields services company employing 123,000 people across 85 countries, see[3]. **Dr Andrew Clarke** is a Principal Scientist in Advanced Recovery at their laboratories in Cambridge whose research focuses on understanding the flow of complex fluids through porous structures.

Dr James Sprittles is a IAS Global Research Fellow in Mathematics for the next 5 years whose details are on his webpage: `http://homepages.warwick.ac.uk/staff/J.E.Sprittles/`.

References

[1] P. S. Hammond. One- and two-phase flow during fluid sampling by a wireline tool. *Transport in Porous Media*, 6:299–330, 1991.

[2] Schlumberger's 'Eclipse' Software. `http://www.software.slb.com/products/foundation/pages/eclipse.aspx#js`.

[3] Schlumberger. `http://www.slb.com`.