ABSTRACT

This thesis presents an analysis of gas evolution and re-dissolution behaviour associated with the depressurisation and repressurisation of hydrocarbon-saturated porous media. A network modelling approach is adopted, whereby the porous medium is represented by an interconnected lattice of well-characterised pore elements of varying sizes. A modified invasion percolation approach is implemented for modelling the advance of gas/liquid interfaces under the combined effects of capillary, gravitational, and viscous forces. A wide range of experimentally observed pore level mechanisms and measured PVT parameters are included in the model, including: bubble nucleation, diffusive mass transport, expansion, bubble fragmentation and coalescence, oil shrinkage, unsteady-state gas migration, and oil re-imbibition.

Network simulations are validated against experimental results, with comparisons providing comprehensive explanations for several poorly understood observations. Under depressurisation, transitions from non-dispersive to dispersive gas flow are found to be influenced by a number of pore-scale petrophysical parameters including; mean capillary entry radius, network connectivity, interfacial tension and pore-size distribution variance. Results show that gas flow regime and experimental protocol crucially affect the definition of critical gas saturation and the value of final gas saturation (an indicator of oil recovery) during pressure depletion.

Repressurisation simulations are also presented and these clearly show how hysteresis in gas saturation between depletion and repressurisation is a manifestation of hysteresis in more fundamental properties including, supersaturation, interfacial area, the total number of gas clusters, and the total mass in the gas phase. Furthermore, secondary depletion following repressurisation can lead to a significant increase in recovery when compared with that resulting from primary depletion.