Hydrodynamic Effects on Membrane Seal Capacity

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Membrane seals rely on capillary processes. In a water-wet system, hydrocarbon permeability is zero when the buoyancy pressure is less than the displacement pressure. Conversely, at irreducible water saturation, the permeability to water approaches zero. However, Bjorkum et al. (1998) suggest that there is some permeability to water and thus a pressure gradient between the free water level and the top of the reservoir. This was confirmed by laboratory based experiments of Teige et al. (2005). A simple extrapolation of the experimental results suggests that excess pressure variations across seals or across faults do not have a direct impact on capillary leakage.

The work of Bjorkum et al. (1998) and Teige et al. (2005) imply that the hydrodynamic regime will not impact capillary leakage. However, these papers only deal with the boundary between the uppermost pore of the reservoir and the lowermost pore of the seal. In a hydrocarbon exploration sense, a seal has failed only if hydrocarbons have breached its entire thickness. It is therefore worthwhile to use the principles established by Bjorkum et al. (1998) and Teige et al. (2005) and re-examine the relation between hydrodynamics and membrane seals in the context of the entire seal thickness. To do this we consider a simple geometry of two aquifers separated by a seal. Various excess pressure conditions are considered and their effect on seal capacity determined. The results from the simple case scenarios are used to define an approach for calibration of seal capacity estimates (top or fault seal).