Differentiating Barriers from Baffles Using Pre-Production Data

Smalley, Craig [1]; Mamode, Hisham [2]; Muggeridge, Ann [2] (1) Exporation & Production Technology, BP, Sunbury on Thames, United Kingdom. (2) Department of Earth Science & Engineering, Imperial College, London, United Kingdom.

Various stratigraphic and structural features have the potential to adversely affect oil recovery by preventing (barriers) or impeding (baffles) fluid flow. This paper discusses methods for identifying the existence of these features from spatial distributions of fluid data such as hydrocarbon density, oil or formation water composition, pressure and contact depths. These types of data are often viewed as "static", but they can in fact have a dynamic component when viewed on a geological timescale.

Variations in fluid properties are created during oil or gas filling of a reservoir; with time these fluid heterogeneities will mix back to an equilibrium state. Where non-equilibrium variations persist to the present day, this can be seen as evidence of a barrier preventing fluid mixing or a baffle slowing the mixing down. A key variable in the interpretation of such data is the time taken for mixing to occur in (a) a fully transmissive reservoir with no barriers or baffles; (b) a reservoir with baffles of various size; (c) a reservoir with very extensive barriers.

We have developed analytic expressions to estimate the time-scales for pressure-driven, density-driven and molecular diffusion fluid mixing processes. These different mixing rates lead to different “length scales of investigation” for the various data types; using these models we have investigated time-scales for fluid mixing in simple reservoir geometries with different fluids (water, viscous oil, oil, gas) and with a range of barrier/baffle sizes/properties, to demonstrate the utility of different data types. For example, pressure would not be a good tool to investigate subtle baffles in a gas field; the pressure equilibrates so quickly that only very extensive barriers would be detected. On the other hand, water compositional differences, mixing only by slow diffusion, may be highly sensitive to even very small baffles around a well, but inappropriate for detecting extensive barriers.

We also demonstrate the data integration workflow for using mixing time-scales to interpret barrier/baffle size, and understand their impact on a production time-scale. We illustrate this with a case study where pressure mixing and gravitational overturning of hydrocarbon-water contacts were used to constrain the impact/existence of a dynamic aquifer in a reservoir containing barriers and baffles to flow such as faults, extensive shales and tar mats.