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Defining an OWC Controlled by Combined Structural, Hydrodynamic and Stratigraphic Effects – A Case Study

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ABSTRACT

Flowing groundwater beneath an oil accumulation causes the oil-water contact (OWC) to be tilted. This hydrodynamic effect has been observed in reservoirs worldwide. A hydrodynamically tilted OWC can further be complicated by stratigraphy. We present a case study from the Arabian Basin to demonstrate a methodology on defining an OWC controlled by structural, hydrodynamic and stratigraphic effects combined. The study field is located in a region termed “Interior Homocline-Central Arch Province”, according to a hierarchical scheme of the U.S. Geological Survey's World Petroleum Assessment 2000, where the sedimentary rock formations tilt eastwards in general. Groundwater in these formations flows down dip eastwards under gravity. The reservoir in the case study is the Upper Permian Unayzah formation. In the study field, the oil accumulation is far beyond the structural closure and different OWC levels are observed in different wells. A hydrodynamically tilted OWC was constructed and compared with the observed OWC. A hydrodynamically tilted OWC surface is defined by (Yang and Mahmoud, 2016): Z_OWC=Z_OWC_0+ρ_w/(ρ_w - ρ_o)*(h_w_0 - h_w) Where, Z_OWC is the depth of the OWC at a given location, Z_OWC_0 is the depth of the OWC at a reference location (well), ρ_w is density of formation water, ρ_o is the density of hydrocarbons, h_w is the hydraulic head at the given location and h_w_0 the hydraulic head at the reference location. The predicted hydrodynamically tilted OWC makes the oil accumulation boundary of the field significantly smaller than the one defined by the closure. The reason is that the spill point of the closure is located on the side of the downdip of the formation and the hydraulic pressure of the ground water acts in the downdip direction. The hydraulic pressure would have flushed some accumulated oil out at the spill point to result in a smaller oil accumulation. It was found that the spill point is blocked by poor quality formation rock. The predicted hydrodynamically tilted OWC was then modified based on stratigraphic information. The modified hydrodynamically tilted OWC fits almost perfectly with the observed OWC. Therefore, the following two conclusion can be drawn from the case study: 1) different OWC levels in wells of the field and the oil accumulation boundary are influenced by combined structural, hydrodynamic and stratigraphic effects, and 2) the tilted OWC of a field can be properly defined if all relevant effects are included.