Re-Building the Reservoir Architecture through 4-D Field-Life Geodynamics: A Waterflood Management Case Study from South of Oman

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Abstract

Objective:
The fluvial/alluvial reservoirs of Gharif formation in the south of Oman has been widely developed but the geological complexity of these reservoirs makes their optimum maturation subjected to the further understanding of their producibility behavior.

In the second development phase - after depletion - of X-field, six of Gharif stacked reservoirs has been developed through reversed 5-spot water flood patterns with commingled vertical oil producers and vertical injectors. However, the water flood management has been a challenge since started due to the complexity of these reservoirs specifically when it comes to the high order of magnitude variations in the permeability and the vertical connectivity. The conventional geological data are not enough to break down this complexity.

Therefore, an initiative was taken to reconstruct the reservoir architecture through integrated geo-dynamic analysis and accordingly define a new strategy for the water-flood management of the field.

Method/Workflow/Data/Tool:
The work initially started by generating a set of pressure maps along the field-life time of each reservoir starting from the early days of the field production through depletion up to date. Then, these maps were linked to the reservoir sand distribution maps. The depletion behavior of each reservoir during the depletion stage was then linked to the water flood performance.

The results from the above method were then calibrated and strengthen using the available production logs and the integrated dynamic plots. In addition, and in order to estimate the remaining oil, the depletion maps were utilized to generate production allocation factors per each reservoir and per each 5-spot water flood pattern.

Results/ Conclusions:
From the above 4-D analysis of the geo-dynamic data, it was observed that the reservoirs that went through faster depletion during the early days of the field production are currently causing water short-circuiting between the injectors and the producers. These reservoirs also have the least remaining oil. Laterally, this phenomenon is also variable within the same reservoir depending on the lateral variations on the reservoir properties.

This integrated geo-dynamic understanding resulted into a new conceptional architecture model of the field. Building such model would not have been possible using the conventional geological/petrophysical data only. This model together with the calculated remaining oil maps has been used to build a new water-flood management strategy to enhance the hydrocarbon maturation of the field.

Novel/ Additive Information:
The analysis of the field dynamic data such as pressure through the field-life time (in 4 dimensions, X-Y-Z and time) and integrating these data with the geology can result into a very solid understanding of the field geo- dynamics. This becomes more important when the reservoirs are complex and the conventional petrophysical data are not enough to have a good prediction of the reservoir's permeability and connectivity.