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Fluid Sensitivity Dynamics in Paleozoic Clastic Systems

Obai N. Shaikh[1], Rayan Kanfar[1], and Mukarram Ahmed[1]

[1]Exploration Technical Services Department, Saudi Aramco, Dhahran, Eastern Province, Saudi Arabia.

ABSTRACT

In central Saudi Arabia, our target formation comprises Paleozoic siliciclastics that are known for their reservoir potential. Several wells have been drilled in this Paleozoic fairway and encountered different fluid types including brine, gas, and oil. Core analysis shows that the rock quality ranges from clean sandstones to silty sandstones. Hence, the depositional environment of these Paleozoic clastics are dominated by semiarid to arid terrestrial settings, such as playa lakes, streams and eolian deposits. We recognize that the hydrocarbon-bearing zones are heterogeneous in terms of lithology and fluid content. A comprehensive rock physics study was conducted to understand the acoustic sensitivity towards fluid properties enabling to explore for high porosity hydrocarbon-saturated zones. The objective of the rock physics modeling is to better understand the relative sensitivity effects of fluid properties on elastic moduli and subsequent AVO responses. Utilizing the average PVT properties from the wells, a comprehensive modelling was carried out to understand the impact of changing fluid properties on the elastic domain. Rock physics analysis suggested that these Paleozoic clastics have a wide range of porosities with varying acoustic velocities, characteristics attributed to their heterogeneous nature. The behavior of the data also indicates an increase in rock's stiffness due to the compaction and the diageneses. Fluid substitution and rock physics elastic attributes were analyzed to predict which elastic domain would be helpful to distinguish between reservoir and non-reservoir rocks. Based on the results of the fluid-sensitivity from the rock physics modeling, elastic properties of our Paleozoic reservoir show dynamics with changes in fluid properties. For example, increasing reservoir temperature consistently increases the density and the bulk modulus of the oil-bearing zones. Moreover, increasing the API, thereby increasing the gas-oil-ratio (GOR) gradually decreases the average density and the bulk modulus. Furthermore, the effect of the reservoir pressure is dependent on the fluid type. For instance, increasing the reservoir pressure of oil-saturated sands increases the density and the bulk modulus. However, increasing reservoir pressure of gas-bearing sands primarily increases the density, whereas, changing reservoir pressure for brine-saturated sands had little to no effect.