MAKERERE UNIVERSITY

QUANTITATIVE RESERVOIR CHARACTERIZATION USING ROCK PHYSICS, SEISMIC AND GEOLOGICAL CONSTRAINTS – EXAMPLES FROM SEMLIKI BASIN IN ALBERTINE GRABEN

BY

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ABSTRACT

The Albertine Graben located in the Western arm of the East African rift valley holds Uganda's oil and gas discoveries. Semliki basin which is one of the existing blocks within the Graben, is an oil prospect which has not yielded the government of Uganda with commercial quantities of oil and gas. In this Basin, there is lack of clear understanding of the lateral distribution of the reservoir properties (porosity, saturation and lithology). This study, therefore, has utilized rock physics modeling together with rock physics templates as well as inverse rock physics modeling to delineate reservoir properties. This analysis is first of its kind in this basin and therefore exhibits high level of novelty in reservoir property determination of this area.

Rock physics permits the integration of geophysical information (well log data and seismic data) and geological constraints (mineralogy, facies, porosity, pressure among other) obtained through field observations and literature review. By combining geology information assists in constraining non-uniqueness during quantitative interpretation. In this investigation, Kanywataba well was first analyzed qualitatively by use of cross plots to ascertain whether the various logs (P-wave velocity versus S-wave velocity, density versus porosity) conform to conventional trends or existing known trends. It was observed that density decreases with porosity and the cross plot of P-wave velocity versus S-wave velocity indicates an increasing trend of the two parameters.

Rock physics models were applied to delineate reservoir properties. The two rock physics models namely; the patchy constant cemented model and the constant cement model described the Upper Pliocene Formation and Upper Miocene Formation respectively. The analysis revealed high sandstone bulk modulus values attributed to the presence of feldspars, micas, and calcareous clays in the reservoir units. The data interpretation or visualization was executed using rock physics templates that provide a quantitative interpretation of reservoir properties based on the area's local geology. The rock physics templates of Vp/Vs ratio versus acoustic impedance indicate 5%gas for Upper Miocene Formation and 50% gas for Upper Pliocene Formation. In both Formations, three lithological zones interpreted as gas sand, brine sand, and shaly sand were observed. Also, Upper Miocene Formation data was compared with selected regions of Turaco 2 and Turaco 3 that indicated perfect match with in the plots of Vp data with Vp modelled Kanywataba well data. This

indicates that, the three wells are in the same or related depositional environment and compaction regime.

With information from the burial history of the sediments within the Albertine Graben and constant cement model, compaction regime was observed. The Upper Miocene Formation indicates the presence of a chemical compaction regime which implies, that it has undergone diagenesis with evidence from logs indicating higher velocities, lower porosity, and some amount of cementation associated with this Formation.

Rock physics models combined with seismic inversion analyzed the reservoir properties of the Basin and their lateral distribution away from the Kanywataba well. The procedure employs inverse rock physics modelling constrained by seismic inversion data in which non-uniqueness and data error propagation issues are taken into account. Both seismic and well log datasets are used in the data calibration. The procedures are designed to obtain the most likely estimate mean, weighted mean and posterior mean of the reservoir properties and there is a good match between measured and modelled porosity data. Fluid saturation data were less successfully predicted, but was most probably a result of lack of real saturation logs for use in the calibration of rock physics model, instead, predicted saturation logs based on Archie's law were used in the calibration process. Misfit between observed and predicted lithology is attributed to the uncertainties in defining the mineral properties. The integrated approach reveals that a high fraction of porosities correlated with the low fraction clay volumes and this indicates two distinct reservoir units interpreted as Oluka and Kakara Formation.

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