Petroleum Potential of the Jamaican Wagwater Trough: New Insight Obtained from 3-D Basin Modeling

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3D basin analysis constrained by outcrop exposures and gravity basement modeling reveal the 700 km2 north-northwest trending Cenozoic Wagwater Trough in eastern Jamaica to be a fault-bounded pull-apart graben that underwent three major stages of tectonic development accompanying Jamaica's tectonic interactions along the northern edge of the Caribbean plate : (Stage 1) Paleocene to Middle Eocene fault mechanical rift associated crustal subsidence (66-51 Ma; β=1.66), (Stage 2) Middle Eocene to Middle Miocene gentle thermal subsidence (51-10 Ma), and (Stage 3) Middle Miocene to Holocene crustal shortening (10-0 Ma; β=0.81). The sedimentation in the trough distinguishes these three tectonic episodes. Clastic alluvial fan and fan-delta sedimentation of the Wagwater and overlying Richmond Formations accompanied the rapid subsidence and marine transgression of Stage 1, while the Yellow Limestone and White Limestone Groups were deposited in the continually deepening and transgressing Stage 2. Stage 3 commenced with a Middle Miocene reversal from dextral to sinistral at a constraining bend, the Wagwater Trough experienced negative tectonic subsidence and subaerial exposure.

Two rifting heat flow models were used to bracket the uncertainty of the present heat flow of the basin (0.96 or 40.2 mW/m2 to 1.4 HFU or 58.6 mW/m2, respectively) in order to construct thermal maturity models of these three tectonic stages. Both values allow for the shale layers of the Richmond Formation to range from mature enough to be in the early oil and mid oil windows for the 0.96 HFU model to middle and late oil windows and gas window for the 1.4 HFU model. The first in situ oil for the rifting 1.4 HFU model commenced at 52 Ma, while that for the rifting 0.96 H.F.U. model at 49 Ma. First expulsion time was 50 Ma for rifting 1.4 HFU case and was 41 Ma for the rifting 0.96 HFU case.

The Richmond Formation has the best reservoir properties in the Wagwater Trough owing to its sandstone lithology and good sorting. Hydrocarbons sourced from Richmond shales, Type II (submarine turbidite deposits), could potentially accumulate in traps based on two cases using outcrop constrained fault data: the impermeable fault model and the permeable fault model. If faults are impermeable, hydrocarbons would be confined to the individual fault blocks. If permeable, most of the hydrocarbons in the Richmond Formation escaped to the surface, with potential traps in the deeper zones only.