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Use of fault-seal analysis in understanding petroleum migration in a complexly faulted anticlinal trap, Columbus basin, offshore Trinidad

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Abstract

In this paper, we present an analysis of hydrocarbon migration pathways within a petroleum field located in the Columbus basin, offshore from the SE corner of Trinidad, West Indies. The reservoir-bearing Pleistocene stratigraphic section in this area consists of shales interbedded with thick, poorly-consolidated sands. The East Mayaro (Mahogany field) structure is a broad 4-way-closed, NE-trending anticline cut by a series of NE-dipping normal faults. Stacked petroleum columns exist within the blocks bounded by these normal faults, and the faults can be clearly seen to bound the accumulations. Integrated fault-seal studies have been undertaken in the area to understand the controlling properties of these faults, and these studies have led to an better understanding of the active petroleum system within the fields of the Columbus basin.

Drilling over the past 30 years has defined the distribution of gas-charged reservoirs within a series of fault-bounded compartments. Shallower reservoirs are petroleum-bearing in the eastern portion of the field. Farther westward on the structure, shallow resevoirs in valid traps are found to be wet and progressively deeper reservoirs become petroleum-bearing (Fig. 1). It appears that the location of fault-sealed accumulations is closely controlled by the larger structural geometry, which changes significantly from the shallower reservoirs to the deeper ones.

Previous attempts to explain the spatial distribution of productive sands within the field relied on the assertion that the NE-dipping normal faults acted as the key routes for hydrocarbons to access the higher reservoirs within the structure. One such model involved initial migration along the large fault on the west side of the field and subsequent migration across both faults and stratigraphy from deep sands in the west to shallower sands in the east. Such models require that the faults acted as both conduits and barriers to fluid flow, either simultaneously or at different times in the filling history of the field. In addition, the tortuous migration pathways implied by such models have limited ability to predict the distribution of hydrocarbons in untested blocks within the field.

Post-appraisal of the most recent delineation drilling shows that most of the hydrocarbon columns in the structure are limited in height by either synclinal spill points within individual fault blocks or cross-fault spill points on the west side of fault blocks. The pattern of hydrocarbon-water contacts within the field suggests that petroleum filled and spilled its way from NE to SW across the structure within individual sands. Vertical migration of hydrocarbons along the bounding faults is not required to explain the distribution of productive sands, and this is consistent with both perophysical data and the known sealing character of the faults. This reservoir filling model serves as a tool for predicting primary targets and column heights in untested fault blocks within the area.

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