Hydrocarbon System and Major Tectonic Events of the Guyana Basin

By K Nibbelink, D Boyce, M Nasser, J Boyce, R Webster and F Cedoz JHI Associates (BVI), Inc.

Located on the northern coast of South America, the Guyana Basin is emerging as a significant hydrocarbon province. Recent discoveries in the deepwater now exceed 5 billion barrels of commercial, recoverable oil which has sparked renewed interest by the exploration community. Historical exploration wells drilled on the shelf demonstrated significant evidence of source rocks and reservoirs, but did not yield commercial hydrocarbon discoveries.

Three significant tectonics events have shaped this emerging hydrocarbon province. First, the Guyana Basin is positioned at the southern tip of the North Atlantic rift, floored in the deep water with oceanic crust surrounded by thick Jurassic thru Neocomian aged Carbonate Platforms. Second, during the Cretaceous rift stage, the South Atlantic Basin opened in a zipper fashion moving first from the south as Africa rotated in a counter clockwise direction relative to South America. This rotation caused a compressional event that created a fold belt between the Demerara Plateau in South America and the Guinea Plateau in Africa and allowed deposition of the Aptian, Demerara river system in Suriname, 110 Ma. During the Upper Cretaceous early drift stage the Berbice river system drained most of northern South America, cut a 1000 meter deep canyon across the shelf, 87 Ma and delivered excellent reservoirs to the deepwater. Very low sedimentation rate in deepwater followed in the Lower Tertiary when the Berbice was captured by numerous smaller river systems and the sediment was stored fluvial, nearshore and shelf environments. Third, during the Miocene, the Andes uplift created a massive influx of sediment deposited at the mouth of the Amazon River and transported by strong longshore currents during sea level high stands into the Guyana Basin.

The impact of these three tectonic events on the hydrocarbon system is profound. The Jurassic deepwater basin surrounded by carbonate platforms allowed deposition of rich marine source rocks in localized sub basins during the Lower Albian, 108 Ma Oceanic Anoxic Event, OAE-1. The Cretaceous opening of the South Atlantic allowed deposition of rich marine source rock during the Canje, Cenomanian/Turonian, 90 Ma OAE-2 over the entire deepwater basin. The hydrocarbon system of Guyana Basin can be summarized by understanding the relationship between three river systems, Aptian Demerara, Upper Cretaceous Berbice and Miocene/Pliocene Amazon and two source rocks, Lower Albian OAE-1 and Cenomanian/Turonian, OAE-2.

The Guyana and Suriname shelf wells demonstrate high quality Cenomanian/Turonian, OAE-2 source rock with vitrinite reflectance data that shows the oil maturity window is between 2500-3000m below mud line (BML) and the gas window starts between 4000-4800m of overburden. The average velocity of the Tertiary/Cretaceous sediment is 1meter/1millisecond, therefore the approximate oil window begins at a depth equivalent to 2.5 to 3 seconds of overburden. As overburden thickness and sediment age are the most impactful components to any basin maturity model, simple isochron maps can be used to estimate source rock maturity over time. The first half of the sediment fill of the Guyana Basin occurred over a 100my time frame, but the second half of sediment fill occurred in less than 10my. This has resulted in less compacted, excellent quality reservoirs buried deeper BML than similar basins and an interesting story on source rock maturity.

The widespread Cenomanian/Turonian, OAE-2 source only entered the oil generation window below 2.5 to 3 seconds of overburden, in response to the massive Amazon sedimentation that occurred in the Late Miocene/Pliocene, 5-10 million years ago. However, the Lower Albian, OAE-1 source entered the oil window during the Paleocene in response to the Berbice sedimentation and had been generating oil for 40 million years before entering the gas window 5-10 million years ago. Based on the overburden isochrons maps we conclude that the major contribution to the commercial oil fields in the deepwater Guyana Basin was oil sourced by the more area limited Lower Albian, OAE-1 source, supplemented by the traditional Cenomanian/Turonian, OAE-2 source.