Temperature Prediction and Maturity Modeling in the Deepwater Guyana Basin

Steven G. Crews[1] and Pierluigi Corradini

[1] Apache Corporation, Houston, Texas

ABSTRACT

The first two wells in the deepwater portion of the Guyana basin were both spudded in the first quarter of 2015: Apache's Popokai-1, in Suriname, and Exxon's Liza-1, in Guyana; Exxon announced a "significant discovery" at Liza-1 in May, 2015. Approximately 10 deepwater blocks in this frontier province have now been leased by various oil companies and further exploration wells are expected soon. This presentation is about the pre-drill petroleum systems modeling at Apache—especially temperature prediction—and how the well results affected our thermal maturity model.

Temperature was seen as an especially sensitive parameter for charge risking in this province, as the postulated Cenomanian-Turonian source rock is clearly immature in much of the region, and the precise location of the edge of the mature kitchen could impact a number of prospects and even entire exploration blocks.

Prior to drilling Popokai-1, the temperature dataset comprised about 30 wells, drilled on the shelf over a period of some four decades; data quality was highly variable. All but one of the existing wells is located in less than 150 m water depth (WD) whereas average WD on the Apache block is over 1600 m. The one existing well drilled in >150 m WD is located on the flanks of the Demerara Rise, a unique tectonic feature very different from the tectonic setting of the Apache block. The average thermal gradient of all wells is about 28 °C/km.

Our approach to predicting the temperature in the undrilled deepwater was threefold:

1. Collect and high-grade all of the data, by filtering it based on time-since-circulation and correctability (some was susceptible to Horner-type correction; most was not).
2. Look for spatial trends and map the thermal gradients in the area of data coverage.
3. Extrapolate the trends into the deep water, using tectonic models for passive margin crustal thinning and crustal composition and estimates of the continent-ocean boundary location obtained from potential fields work.

Because of the uncertainty inherent in the extrapolation to deep water, we attempted to capture the range of possibilities using "cool" and "warm" end-member scenarios. In the cool scenario, a sharper and more landward transition from continental to oceanic crust was envisioned.

Popokai-1 collected abundant high-quality temperature data that agreed more closely with the "warm" model, in which little additional cooling was postulated between the closest existing well and the Apache block; the thermal gradient is only slightly less than the basin average, at about 26 °C/km. We currently believe that this was partly due to the magnitude of crustal attenuation being less than predicted in the cool model, but also because of lithology-conductivity effects—the Neogene section is shalier than modeled. Interestingly, transient effects created by rapid Plio-Pleistocene burial reduce the impact on thermal maturity of the relatively high temperatures.