10/08/2015; 8:00AM

3D Delaware Basin Model: Insight into its Heterogenous Petroleum System Evaluation as a Guide to New Exploration

John D. Pigott, Esra Yalcin, Kulwadee L. Pigott, and Michael Williams
University of Oklahoma

The post Silurian evolution of the Delaware Basin and its interior petroleum systems is complex and not amenable to a simple depth -dependent maturity model. An integration of 1D, 2D and 3D basin models incorporating stratigraphic-lithologic-geochemical-thermal information gathered from 150 wells in the basin reveal four major tectonic episodes: (1) The Tobosa Rifting Phase (488-320 Ma), (2) The Permian Basin Phase (320-250 Ma), (3) The Stable Platform Phase (250-80 Ma), and (4) The Cenozoic Tectonic Uplift Phase (70-0 Ma). Heat flow values determined from these well borehole temperatures and lithologic conductivities range from 0.6 to 1.4 HFU, with an average of 1 HFU, and show higher heat flows in the western relative to the eastern side of the basin. However these present day heat flow values inverse geovalidated by vitrinite reflectance (Ro%) and pyrolysis maximum temperature (Tmax) measurements are not the product of simple crustal extension, but instead result from episodes of stretching and flexure which have varied spatially through the basin. Whereas rapid subsidence during the Permian is caused by tectonic crustal stretching on the western side of the Delaware basin, subsidence on the southeastern side of the basin which is proximal to the Marathon-Orogenic belt and Central Basin Platform thrust fault is a product of lithospheric flexural downwarping. The effects upon hydrocarbon maturities are profound. The 1D and 2D models illustrate the western side of the basin to have higher vitrinite reflectance maturity values. Whereas in the west the Simpson is already in late mature oil window, the Woodford and Barnett are

in the mid mature oil window and the Wolfcamp is in Early oil window. By comparison, in the southeastern of the basin, the Simpson is mid mature, and the Woodford and Barnett shales are in the early oil window. Consequently, 3D maturity-migration pathway mapping reveals large oil and gas traps to be located on local highs within the depocenter of the basin, to the northeast, and on Central Basin Platform for the Woodford, Barnett and Wolfcamp. However the Bone Spring, the youngest source rock defined in this study, exhibits migration pathways which vector both toward the western edge of the basin and pond in possible sweet spots to the East. The detail of these generated maps suggest a heterogeneity of potential stratal-dependent fairways for existing and future conventional – unconventional petroleum exploration strategies.