

Examination of Downward Hydrocarbon Charge within the Bakken – Three Forks Petroleum System, Williston Basin, North America

Timothy Nesheim

ND Geological Survey

9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

The Bakken and Three Forks Formations of the Williston Basin have been targeted by over 10,000 unconventional style wells (horizontal drilling coupled with hydraulic fracturing). Exploration and developmental drilling initially focused on the middle Bakken but later expanded into the underlying upper Three Forks (located directly below the Bakken) and eventually the middle to lower Three Forks, positioned 10s to 100+ feet below the Bakken. Hydrocarbons (oil and associated gas) within both formations are believed to be sourced from the upper and lower Bakken shale members, which are both highly organic-rich (>10% TOC), thermally mature petroleum source beds. However, minimal literature exists examining the relationship between hydrocarbons generated by the lower Bakken shale and expelled downward into the various reservoirs of the Three Forks. Core-plug data from 65 cores was utilized to map out fluid saturation trends within the Three Forks Formation. Geochemical data from 52 cores and wireline logs of 240 wells were used to examine the thermal maturity and thickness of the lower Bakken shale, the supposed source rock for Three Forks hydrocarbons. Lastly, the geochemical and core-plug data were combined to calculate and compare the volumetric amount of oil generated and expelled from the lower Bakken shale with the original oil in place (OOIP) of the entire Three Forks section. A strong spatial relationship exists between increased thickness-thermally maturity of the lower Bakken shale and elevated core-plug oil saturations across the upper to middle Three

Forks members, and a less pronounced relationship with the lower Three Forks. The calculated lower Bakken shale expelled oil volumes of 13 to 51 million barrels of oil (MMBO) per 640 acres overall equal to exceed the OOIP of the entire Three Forks section (9 to 25 MMBO/640 acres). These spatial and volumetric relationships indicate that local hydrocarbon generation and expulsion from the lower Bakken shale is the primary control for hydrocarbon charge within the underlying Three Forks Formation, where in some locations hydrocarbons have moved downwards 200+ ft. Understanding downward hydrocarbon charge has exploration and development implications within the Bakken-Three Forks Formations as well as numerous other unconventional petroleum systems.