Examination of the Red River (Yeoman-Herald Formations) Petroleum System

Timothy O. Nesheim[1]

Abstract

The Upper Ordovician Red River Formation (~Herald and Yeoman Formations of Saskatchewan) has been a prolific producer of oil and gas across the Williston Basin. The Red River ranks third in cumulative basin-wide hydrocarbon production amongst dozens of productive stratigraphic horizons, and only trails behind the Bakken-Three Forks Formations and the Madison Group. Over 2,800 Red River wells, extending from southern Saskatchewan, Canada to northwestern South Dakota, United States, have cumulatively produced approximately 560 million barrels (8.90×10^7 m^3) of oil and 1.1 trillion cubic feet (3.11×10^{10} m^3) of gas (~200 million barrels of oil equivalent). Petroleum source beds (kukersites) in the Red River D zone (upper Yeoman) are estimated to have generated approximately 66 billion barrels (1.05×10^{10} m^3) of oil equivalent beneath western North Dakota. Thermally mature kukersites extend beyond western North Dakota, including southern Saskatchewan, and thus the estimated generated hydrocarbon volume is incomplete. Even still, cumulative, basin-wide Red River production only accounts for roughly 1% of the estimated, incomplete generated volume, and therefore a substantial amount of resource may remain within the Red River.

The D zone (upper Yeoman) constitutes one of the primary reservoirs within the Red River Petroleum System and contains the thermally mature kukersites (petroleum source beds). The D zone has also been the primary target of recent exploratory and development drilling in the Red River across various portions of the Williston Basin. The D zone consists primarily of burrow-mottled carbonate wacke-mudstone in which tight limestone (<2% ϕ) and porous dolomite (up to 25% ϕ) grade both laterally and vertically between one another. The discontinuous nature of the porous dolomite essentially forms localized stratigraphic traps that can now be more easily identified and targeted in the subsurface using modern 3-D seismic. Across western North Dakota, and possibly beyond, D zone reservoirs are locally charged by the interbedded, thermally mature kukersites. However, the localized hydrocarbon charge is in some cases partially to near completely lost through vertical migration along faults/fractures that breach the low porosity limestone and kukersite beds that form hydrocarbon seals. Several other factors appear play roles in D zone hydrocarbon production as well, including: source bed (kukersite) thermal maturity as well as the API oil gravity and gas to oil ratio of producible hydrocarbons. Re-examination of these various factors that control Red River production, particularly in the D zone, numerous opportunities appear to be present for additional development in existing Red River Fields as well as continued exploration in prospective, undeveloped areas.

[1]North Dakota Geological Survey

Timothy O. Nesheim is a subsurface geologist with the North Dakota Geological Survey (NDGS). He earned a B.S. degree in geosciences from the Minnesota State University of Moorhead (2007), a M.S. in geosciences from the University of Iowa (2009), and spent time as a full-time research assistant at Washington State University. Tim has been with the NDGS since 2010 where he has focused on investigating the geology of various oil and gas producing formations.