Geology and Hydrocarbon Potential of the Black Island Formation, Winnipeg Group (Ordovician) in North Dakota

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Abstract

Across western North Dakota and southeastern Saskatchewan, 33 vertical wells have produced oil and/or gas from the Winnipeg Group (Black Island Fm.). Hydrocarbon production from these 33 wells transitions from dry gas production at depths of >13,000 ft. (Gas to Oil Ratios >900) to wet gas (GOR's 40-400) to oil production (GOR's <1), indicating the Winnipeg Petroleum System contains dry gas, wet gas, and oil windows.

The Winnipeg group extends throughout parts of North Dakota, Montana, South Dakota, Saskatchewan, and Manitoba. The clastic-dominated Winnipeg Group was deposited during an Ordovician aged marine-transgression upon an unconformity, developed on the Cambrian-Ordovician aged Deadwood Formation or Precambrian surfaces, and is conformably overlain by the carbonate Red River Formation.

The Black Island Formation is the basal unit of the Winnipeg Group and the primary target of Winnipeg completions. The Black Island Formation consists of interbedded, bioturbated shaley to silty sandstones (subtidal, offshore deposits) and cross-bedded to massive, medium grained, mature sandstones (foreshore/shoreface deposits). The likely source of hydrocarbons within the Black Island Formation is the overlying Icebox Formation (middle Winnipeg) which is composed of primarily green to grey to black shale deposited in an offshore-shelf marine environment. Total Organic Carbon (TOC) wt. % measured off of Icebox drill cutting samples ranged from 0.11 to 2.32% (0.55% avg.) and 0.12 to 4.33% (0.57% avg.) for core samples.

The upper Black Island Formation (Garland Member) contains three regionally extensive, fine to medium grained, well sorted, well rounded sandstone intervals (foreshore/shoreface deposits). These sandstone intervals can be mapped using their low, clean gamma ray signature, and vary from 0 to over 40 ft. thick. Core analyzes from the central, deeper portions of the basin, where these sandstone intervals appear to be in the dry to wet gas window, average 0.31 millidarcies of permeability and 5.2 % porosity with 13.0 % oil saturation and 26.0 % water saturation. The stratigraphically lowest and thickest of these foreshore/shoreface sandstone intervals averages 20-30% log calculated water saturation (Rw = 0.044 @ 75°F, ϕ = sandstone matrix density porosity) across the central portions of the basin, and therefore may have upwards of 70-80% hydrocarbon saturation.

Based on limited production, log, and core data, completing an economic Black Island well appears to be more a function of establishing adequate flow rates than finding hydrocarbon saturated intervals. Combining log and core information, the Black Island Formation may be a viable unconventional target yielding dry gas to wet gas to oil dependent upon such factors as depth, heat flow, source rock quality and kerogen type.

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