

Conceptual Petroleum Plays in Peel Plateau and Plain, Northwest Territories and Yukon

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Summary

The Peel Petroleum Project (2005-2009) was initiated by the Northwest Territories Geoscience Office and involved partners from the Geological Survey of Canada, Yukon Geological Survey, universities, and industry. A study of hydrocarbon potential and regional geology in the Peel Plateau and Plain (Peel area) of the Northwest Territories and Yukon addressed the need for modern petroleum geoscience data and interpretation in this underexplored, yet prospective, area in proximity to the proposed Mackenzie Gas Project natural gas pipeline route. A total of 74 wells have been drilled in Peel Plateau and Plain. None of these wells have been productive, but indications of petroleum systems in the Peel area include petroleum shows in exploration wells, gas seeps, oil stained outcrops, and bitumen occurrences. Fieldwork was conducted on the Phanerozoic succession in the northern Mackenzie Mountains, Richardson Mountains, and Franklin Mountains that expose stratigraphy contiguous with the subsurface of Peel area.

The final project volume (Pyle and Jones, 2009) includes structural and seismic interpretation, regional stratigraphy, and a review of petroleum systems elements for the area. A Geographic Information System digital atlas (Pierce and Jones, 2009) accompanies the project volume and contains all of the spatial data associated with the research. The interactive atlas includes field and core photographs, interpreted seismic profiles, core and measured section descriptions, geochemical analyses, isopach and structural contours, and other related data associated with a spatial database of wells and field localities.

This poster highlights project results with emphasis on the conceptual petroleum plays in Peel Plateau and Plain: Basal Cambrian clastics play, Lower Paleozoic platform play, Arnica-Landry play, Kee Scarp play, Imperial Formation play, Tuttle Formation play, and Basal Cretaceous sandstone play.

The Basal Cambrian Clastics play includes all pools and prospects hosted in sandstones of Cambrian Mount Clark and Mount Cap formations (Pyle and Gal, 2009a). No data on potential reservoir characteristics are available from these formations in Peel area, but one outcrop sample of Mount Cap sandstone southeast of Peel area yielded 4.4% porosity and 0.03 millidarcies (mD) permeability. Potential Cambrian source rocks in Peel area are not thick and generally yielded less than 0.5% total organic carbon (TOC). Evidence for a Paleozoic (Cambrian to Ordovician) source of oil comes from new solvent extraction analysis of oil-stained Devonian outcrop samples (Gal et al., 2009a). Possible traps include updip depositional pinch-outs against paleotopographic highs, intraformational facies changes from sandstone to shale,

and intraformational diagenetic changes affecting porosity. Limited data from Peel area precludes constraints on timing of petroleum generation, migration, and possible accumulation.

The Lower Paleozoic Platform play is a conceptual play in Peel area that consists of all pools and prospects hosted in porous dolostones of Ordovician to Silurian Franklin Mountain and Mount Kindle formations, and possibly quartz sandstones in basal Franklin Mountain Formation (Pyle and Gal, 2009b). Potential reservoir intervals may be on the order of tens of metres thick. Franklin Mountain outcrop samples yielded a range of 1.7% to 9.4% porosity and a range of 0.02 to 1.07 mD permeability; subsurface porosity values (weighted average) are up to 6.7%. Mount Kindle outcrop samples yielded a range of 1.5% to 9.7% porosity and a range of 0.005 to 1.51 mD permeability; subsurface porosities are up to 6.7% with permeabilities up to 21 mD. Potential source rocks are Road River Group shales (outcrop samples yielded up to 6.14% TOC), which are overmature and likely dry gas generating. A variety of stratigraphic (e.g., interfingering facies at the platform edge) and structural traps (faulted anticlines in southern Peel area) are possible. Exploration risks for this play include distribution of potential reservoirs, communication with source rocks, formation of closures, viability of top and lateral seals over time to preserve hydrocarbons, and timing of trap formation relative to hydrocarbon migration.

The Arnica-Landry play includes all pools and prospects hosted in vuggy, porous, and fractured carbonate and carbonate breccias (Bear Rock facies) of Middle Devonian Arnica and Landry formations (Gal et al., 2009b). Potential reservoir intervals in Arnica Formation and Bear Rock facies are tens of metres thick with 3 to 10% porosity and permeabilities between 1 to 2 mD. Porous limestone with up to 4 to 6% porosity occurs in Landry Formation. Few suitable source rocks occur within these carbonate units, thus reported shows are more likely associated with overlying Hare Indian and Canol Formation source rocks. A variety of traps are possible including up-dip pinch outs of porous facies, fault traps, traps associated with carbonate to shale transition, and dolomitization (Dixon et al., 2007). In addition, traps in eastern Peel area may include patch reefs within Arnica Formation and porosity traps related to karsting in the eastern extent of Arnica-Landry exposures (Gal et al., 2009b). Exploration risks for this play include timing of trap formation relative to hydrocarbon migration, closure of traps, and isolation from effective source rocks (Osadetz et al., 2005).

The Kee Scarp play includes all pools and prospects hosted in the stromatoporoid-coral “reefs” or banks of Kee Scarp member of Ramparts Formation (Gal et al., 2009b). The play is conceptual in Peel area because no economic discoveries have been made. The play is established in Mackenzie Plain, southeast of Peel area, based on the Norman Wells field. Porous limestone in Ramparts Formation has 6 to 10% porosity and permeabilities in the 1 mD range (in reservoir intervals 10 to 20 m thick). Source rocks for the play include Middle and Upper Devonian shale of Hare Indian, Ramparts, and Canol formations. TOC values for Bluefish Member and Ramparts Formation are high (average TOC = 6.68% and 5.05%, respectively), indicating excellent potential; both units range from mature to overmature in Peel area. Outcrop samples from Peel area confirm the excellent source rock potential of Canol Formation (average TOC = 4.85%), which ranges from immature to post-mature in Peel area. Potential traps are likely stratigraphic for the Kee Scarp play. This play has the lowest exploration risk of all the plays in Peel area; however, risks include reservoir quality, trap formation (breaching of large structures), and lack of viable seal (Gal et al., 2009b).

The Imperial Formation play includes all pools and prospects hosted in porous, very fine-grained quartzose sandstones of Upper Devonian to Carboniferous Imperial Formation. Reservoir rocks from surface samples yielded a range of 0.5 to 24.7% porosity and permeabilities between 0.005 to 0.18 mD (Hadlari et al., 2009a); weighted average porosity up to 18.1 % with 312 mD permeability were estimated from well logs (Hu, 2009). Well and outcrop

samples of intraformational source rocks yielded an average of 1.75% TOC; Imperial Formation is generally mature to overmature in Peel area. Both stratigraphic and structural traps are possible, such as channelized sandstone or lateral pinch-outs of sandstone beds, interfingering relationships of Imperial and Tuttle formations, and minor folds and fault-bound structures (Pyle et al., 2008). Play-scale risks include insufficient source rocks, reservoir quality and thickness, and closure of stratigraphic traps (Hadlari et al., 2009a).

The Tuttle Formation play includes all pools and prospects in porous sandstone and conglomerates of Upper Devonian to Carboniferous Tuttle Formation. Reservoir rocks from outcrop have porosity ranges from 2 to 26% and permeability ranges from 0 to 127 mD; and 11.1 to 24% porosity in subsurface samples (Allen et al., 2009). Source rocks include intraformational shales (values between 1 and 2 % TOC), and Ford Lake Shale (averages 4.63% TOC). Tuttle Formation is within the oil window through much of Peel Plateau, and maturity increases westward toward the Richardson Mountains. Oil stained samples of Tuttle Formation and Ford Lake Shale were likely sourced in the Late Paleozoic (Allen et al., 2009). Play-level risks include shallowness of potential reservoir rocks through Peel area (Gal et al., 2009a).

The Basal Cretaceous sandstone play includes all pools and prospects in the basal marine sandstone of Martin House Formation (Hadlari et al., 2009b). Outcrop samples of potential reservoir rocks yielded porosity up to 21.5% and permeability up to 58.2 mD. Source rocks include shales of Martin House (up to 1.5% TOC), Arctic Red (up to 3.54% TOC), Slater River (up to 2.69% TOC), and Trevor formations (up to 2.2% TOC). Samples suggest Cretaceous strata are within the oil window in most of Peel area, and in the gas window in western areas. An exploration risk is a structurally favourable setting that predates maximum burial in the latest Cretaceous to Tertiary (Hadlari et al., 2009b).

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