

Review of the Structure and Stratigraphy of Phanerozoic Deposits in the Mackenzie Delta, NWT, Canada

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Summary

Since the 1940s, the geological regions that comprise the Canadian Arctic Continental Shelf (CACS) and particularly the Beaufort-Mackenzie Basin (BMB) has been explored for oil and gas prospects. Exploration work consisted of geological field surveys, acquisition, processing and interpretation of reflection seismic data, and drilling of exploratory wells. To date, 180 of 263 exploratory wells drilled in the Beaufort-Mackenzie Basin (BMB) are located onshore in the Mackenzie Delta (Osadetz et al., 2015). Also, over 21000 kilometers of 2D Seismic surveys conducted both on and off-shore are available publicly. Data from more than six decades of research activities by government geological surveys and the oil and gas industry facilitated the estimate of petroleum reserves of up to $172.72 \times 10^6 \text{ m}^3$ recoverable crude oil and condensate, and $254.67 \times 10^9 \text{ m}^3$ marketable conventional gas for the region (Osadetz et al., 2015). To further refine the Mackenzie Delta's oil and gas potential, as well as its carbon sequestration (CS) potential, the Government of Northwest Territories' (GNWT) Northwest Territories Geological Survey (NTGS) and Mineral and Petroleum Resources Division (MPRD) commenced the new study project of the Mackenzie Delta and surrounding basins. This study will focus on the structural and stratigraphic elements that host the Mackenzie Delta's oil and gas reserves and may have potential for CS. The study will synthesize legacy data obtained from geological field surveys of the Mackenzie Delta and the adjacent basins and mountains, and will include new field work to be conducted in the summer of 2023. Newly acquired rock samples will undergo laboratory analyses including source-rock analysis, petrography, lithochemochemistry, palaeontology, and mineralogy; these results will be merged with legacy data of similar nature. Workstation interpretation and analyses of digital subsurface data for the purpose of basin modeling will be carried out. Central to the outcome of this work will be a regional 3D basin model that will represent the geochemical, sedimentological, stratigraphic and structural characters of the basin, which can be applied to improve our understanding of the hydrocarbon systems on the Mackenzie Delta and aid the potential discovery of previously unknown reserves. This project also aims to delineate potential targets for CSS.

Basis for Study

The BMB is an important northern Canadian geological frontier that holds a great significance for the North American energy security owing to its discovered reserves of hydrocarbons. The adjacent basins also hold some significance in providing geological insights into the characters

of the strata and the origin of hydrocarbon resources buried in the BMB. Early field studies of the Mackenzie Delta were conducted in the 1950s and those studies were reviewed and extended to the Richardson Mountains, Caribou Hills, Horton River and Aklavik Range in the 1980s (Dixon, 1996). Dixon et al. (1992) presented a basic geological and geophysical framework for the study area, upon which detailed analysis and interpretation was recommended. Other previous surveys carried out in the region have also revealed possible correlation between rock outcrops in the Richardson Mountains and strata logged in wells in the Mackenzie Delta (Dixon et al., 1992; Wielens, 1992; and NOGD-INAC, 1995).

Interpretation of data from oil and gas wells, and 2D and 3D seismic regional surveys provided basis for stratigraphic and structural framework and have been the subject of various research studies. Mackenzie Delta sediment deposition began after the formation of the foreland basin of the Western Canada Sedimentary Basin in the Early Cretaceous (Bergquist et al., 2004) with the Smoking Hill/Boundary Creek sequences, which are predominantly organic rich mudstones. The accommodation for deposition is provided by the Late Jurassic to Albian continental rifting that produced the graben-like Kugmallit Trough - a major bounding fault that is well defined in seismic surveys (Lane, 2002). These Late Cretaceous black mudstones are overlain by a 12 -16 km thick succession of Tertiary deltaic, shelf, slope, and deep-water deposits comprising the Fish River, Aklak, Taglu, Richards, Mackenzie Bay, Akpak, and Shallow Bay Formations and Iperk Sequences (Dixon, 1992; Chen et al., 2021; Christopher et al., 2004).

Despite these early advances in research, few public domain geological research projects aimed to study rock outcrops in and around the Mackenzie Delta. Data are especially scarce in the surrounding Richardson Mountains and Caribou Hills. A fresh field study of the Mackenzie Delta and the surrounding basin creates an opportunity to augment existing analog data with new digital data at a higher resolution than previous studies.

The GNWT's research program aims to build an integrated structural and stratigraphic framework for Mackenzie Delta with subsurface data calibrated with established analogues from rock outcrops from surrounding basins - the Richardson Mountains, Peel Plain, Peel Plateau and Anderson Plain. A 5-year integrated approach will gather data from rock outcrops, laboratory analysis of samples, and desktop studies of the subsurface data including seismic and well logs. The study will add significant contributions and scientific support for the natural gas resource development in the Mackenzie Delta while also providing viable carbon sequestration solutions.

Workflow

A reconnaissance study using satellite imagery has identified potential rock outcrops in quarries, river cuts, and escarpments along the Dempster Highway south of Inuvik, Mt. Goodenough, Mt. Gifford, Big Fish Creek, Little Fish Creek, Aklak Creek, Martin Creek, Boundary Creek, and Caribou Hills (Figure 1). Field work is planned to these locations in the summer of 2023. Field data from each site will comprise formation thickness and location, photographic records, and spectral gamma-ray measurements. Rock samples will be collected from each outcrop for source-rock, lithochemical, mineralogical, petrographic, and palaeontological analysis. Laboratory analyses of samples will inform the age and depositional environment of the samples, and determine the reservoir properties of the porous rocks, and source-rock thermal maturity and type, and total organic carbon content. Deliverables will include a fresh knowledge base and data asset for surface and subsurface strata of the Mackenzie Delta, updated maps, high-resolution

structural and sequence stratigraphic framework, and possibly a reviewed and updated hydrocarbon resource assessment. This study will also analyze the carbon capture potential within the subsurface of the Mackenzie Delta.

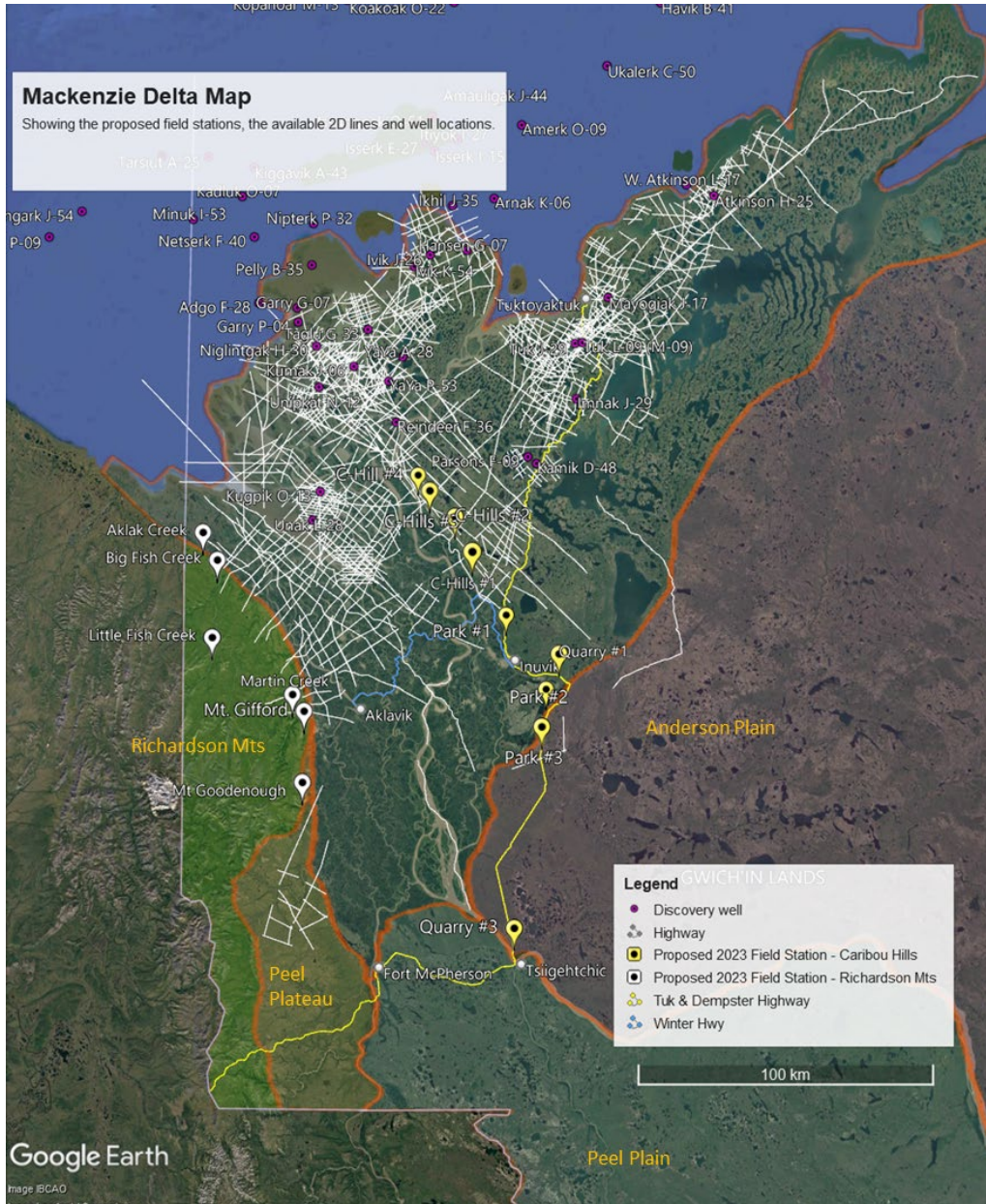


Figure 1: Map of the Mackenzie Delta showing proposed field locations and 2D seismic track lines intended for subsurface structural interpretations and model framework (background image Google Earth).

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