

Folding and Faulting Patterns of the Northeastern Mackenzie Mountains: Implications for Petroleum Exploration

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During an assessment of regional hydrocarbon potential, the relationship between folding and faulting within the northeastern Mackenzie Mountains was reexamined, with a focus on the Plateau Fault (MacNaughton et al., 2008). The result is a reinterpretation of the Plateau Fault, and new insight into regional structural characteristics, with implications for understanding the structural styles and hydrocarbon potential.

In contrast to the Rocky Mountains, the Mackenzie Mountains are noted for: a fold-dominated, rather than fault-dominated structural style; bi-symmetrical rather than asymmetrical vergence (i.e., both foreland and hinterland verging structures are present); a wider deformed belt; and smaller displacements on individual structures. Based on structural style, the northern Mackenzie Mountains can be subdivided into two domains: a northeastern broad-fold domain, and a southwestern fold-and-fault domain.

Within the northeastern domain, broad, open, long-wavelength (8-12 km) folds predominate. Anticlines are cored by a competent, 1.3 km-thick orthoquartzite succession of the Proterozoic Mackenzie Mountains Supergroup, and are inferred to be detached within underlying shale and siltstone approximately 1.2 km thick. Superimposed on the long-wavelength folds are shorter-wavelength (1 km) folds in Middle Devonian carbonate units, most likely detached within underlying Devonian shaly carbonate. Locally, these folds are modified on one or both limbs by reverse or thrust faults with estimated displacements of less than 2 km. By contrast, faulting is more pervasive and long-wavelength folds are absent in the southwestern domain. Shorter-wavelength folds are prevalent in this region because of the greater shale content in the Proterozoic Windermere Supergroup and Paleozoic Selwyn Basin strata, relative to the abundance of thick, competent packages of orthoquartzite in the Mackenzie Mountains Supergroup.

The transition between the domains is marked by NE-directed, NW-trending thrust faults that cross Wrigley Lake (NTS 95M) and Mount Eduni (NTS 106A) map areas, at which Proterozoic strata have been thrust over folded Paleozoic strata. This transition zone encompasses significant northeastward depositional thinning of Proterozoic and Paleozoic strata. The Plateau Fault is the most notable of the transition zone faults, due to its large stratigraphic separation and its long strike length.

Structural analysis of the Plateau Fault, incorporating recent revisions to stratigraphic relationships across it, suggests displacements between 5 and 15 km. This is significantly less than the 35 km estimate of Cecile et al. (1982), but greater than the 2-6 km displacement estimate of Gordey (1981).

Recent field work has documented upright and overturned synclines involving Paleozoic carbonate and shale in the Plateau Fault footwall. The overturned synclines introduce the possibility of carbonate reservoir strata being positioned above carbon-rich shale - in this case the Canol Formation, a known hydrocarbon source rock. In some places, further modification of the synclines by thrust or reverse faults has placed reservoir strata in contact with the potential source rock (Figure 1). This geometry is locally present on faulted fold limbs within the broad-fold domain northeast of the Plateau Fault. Exposed examples include the Tigonankweine Fault

and the southern Gambill Fault. In the latter case the Middle Devonian carbonate overlying the Upper Devonian shale is petroliferous.

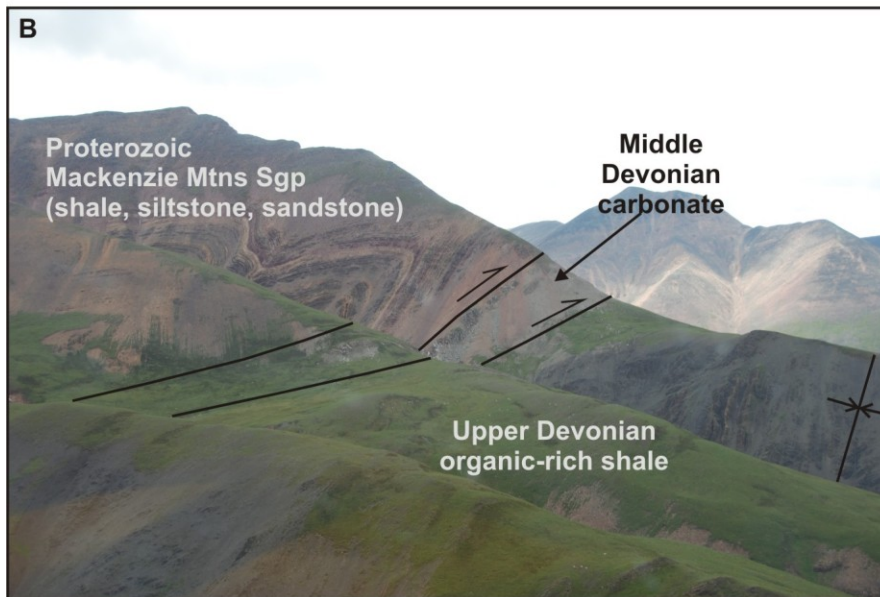
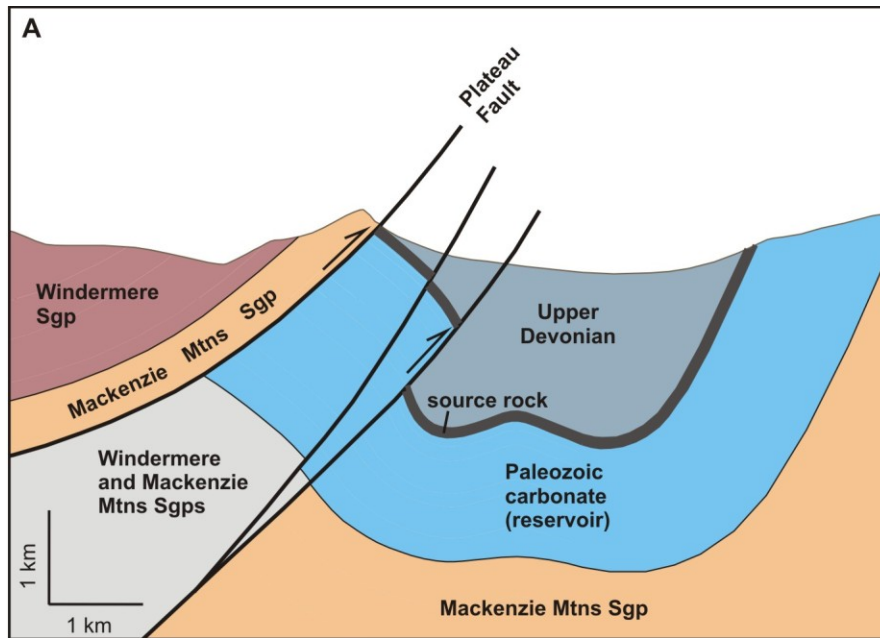


Figure 1. A) Schematic diagram of Plateau Fault footwall relationships favourable for hydrocarbon trapping. B) Example from the Tigonankweine Fault of exposed structural relationships similar to those in A. Mackenzie Mountains Supergroup siliciclastics are thrust over a potential reservoir unit, in turn thrust over a known source rock folded into a tight, upright to overturned syncline. Farther along strike these relationships may be present in the subsurface.

Since this geometry is present in some surface exposures, it is also expected in the subsurface, possibly in a narrow footwall zone (less than 4 km wide) extending down-dip along a fault from the surface trace. Where developed, this overturned footwall geometry could provide favourable conditions for structural trapping of hydrocarbons in the northeastern Mackenzie Mountains.

Trap potential is enhanced in the northeastern Mackenzie Mountains by low-permeability shale directly above many fault surfaces, which could seal reservoir strata in the footwall.

A key conclusion of this study relative to previous work is that the northeastern Mackenzie Mountains may preserve numerous potential structural traps. However, any potential plays would be volumetrically much smaller than the regional Plateau Fault play hypothesized by Cecile et al. (1982). Current understanding of the region's thermal maturity and potential source and reservoir units (e.g. MacNaughton et al., 2008) suggests that such plays would likely be high-risk targets for exploration.

Acknowledgements

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