

Structural Style in the Peel Region, NWT and Yukon

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Summary

The frontal ranges of the northern Mackenzie Mountains, Northwest Territories, exhibit an abrupt change in structural trend from predominantly N-S in the Mackenzie Plain to E-W in the Peel Plateau area, and N-S again in the Richardson Mountains, Yukon Territory, resulting in a very pronounced arcuate shape. Across the Mackenzie Plain Basin, the Franklin Mountains mirror the changes in the structural trend and parallel the Mackenzie Mountains for a distance of 600 km.

This paper summarizes results from the integration of approximately 9,000 km of 2D reflection seismic data, constrained by more than 100 wells and regional and detailed surface geology in the Peel Plateau and Plain (Peel Region) and northern Mackenzie Plain, Northwest Territories and Yukon. We study the variations in structural style along the foothills of the northern Mackenzie Mountains and the Richardson Mountains and relate them to the mechanical properties of the stratigraphy involved.

The interpreted style of deformation in the region is thin-skinned, regardless of whether the Proterozoic strata involved are metamorphosed or not. The subsurface structure at the mountain front of the northern Mackenzie Mountains and Richardson Mountains is dominated by classic triangle zone geometries and tectonic wedging developed at different stratigraphic levels in Neoproterozoic to Cretaceous strata. In contrast, the prevailing deformation style beneath the northern Mackenzie Plain and Franklin Mountains is a hybrid of detachment folding and fault propagation folding related to the presence of the Evaporite Member of the Upper Cambrian Saline River Formation.

Structural Interpretation of the Eastern Flank of the Richardson Mountains

The eastern flank of the Richardson Mountains (Figure 1) is defined for more than 250 km by the Trevor Fault. The Trevor Fault outcrops discontinuously as a N-S trending high-angle fault that for most of its length juxtaposes highly deformed Upper Devonian and Carboniferous strata to the west with relatively undeformed Cretaceous strata to the east. In the Geological Survey of Canada map compilations the fault appears as having a normal relative sense of displacement (downthrown block to the east).

Subsequently, the Trevor Fault has been re-interpreted as an ancient dextral strike-slip system with cumulative shear from mid-Proterozoic to the end of the Devonian, reactivated mainly as a dip-slip fault during Cordilleran deformation (Norris, 1985 and 1997). Hall (1996) interprets the Trevor Fault as a west dipping, east-verging thrust fault rooted in the upper crust and ramping below Proterozoic metasediments; whereas in Osadetz (2005), the outcropping Trevor Fault is interpreted as a hinterland-verging antithetic thrust developed above a larger east-verging fault. The geometry presented for the same feature by the National Energy Board (2000), is that of a high angle (almost vertical) strike-slip fault and related flower structures.

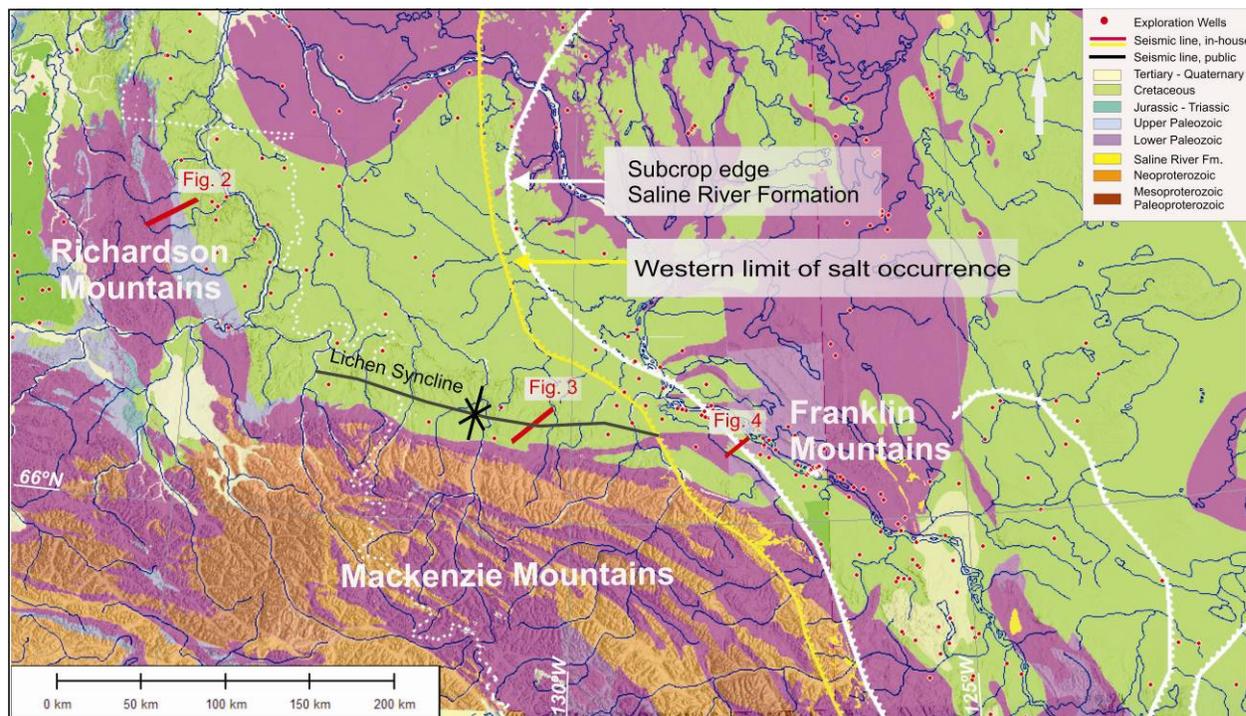


Figure 1: General Location Map, Peel Plateau and Peel Plain, Northwest Territories and Yukon.

The seismic line presented in Figure 2 intersects the mapped surface trace of the Trevor Fault at a location that corresponds with the sub-Cretaceous angular unconformity. The geometries observed in this and several other adjacent seismic lines do not allow the interpretation of a high angle fault at this locality. Instead, a major foreland-verging thrust (that we labeled Trevor Fault) bounds the Richardson Anticlinorium to the east. According to the surface geology, this major thrust does not outcrop east of these seismic lines; it is interpreted to be bedding parallel in the shales of the Imperial Formation.

We interpret classic triangle zone geometries caused by intercutaneous wedging at the leading edge of the Richardson Anticlinorium, where the base of the wedge is an east-verging thrust ramp, the Trevor Fault. The upper boundary of the wedge is a hinterland-verging thrust, bedding parallel in the shales of the Imperial Formation. The numerous subvertical east-dipping faults and small scale structural complications reported from field geology correspond to backthrusts and imbrication of the Upper Devonian Imperial and Tuttle formations in the hangingwall of the Trevor Fault. The allochthonous rocks in the intercutaneous wedge consist of Proterozoic and Cambrian to Lower Devonian strata that outcrop in the core of the Richardson Mountains.

The interpretation of an intercutaneous thrust wedge on the eastern flank of the Richardson Anticlinorium and a blind Trevor Fault adequately explains the variety of geometries observed in the subsurface and the historical difficulty in identifying and tracing a single “Trevor Fault” in the field.

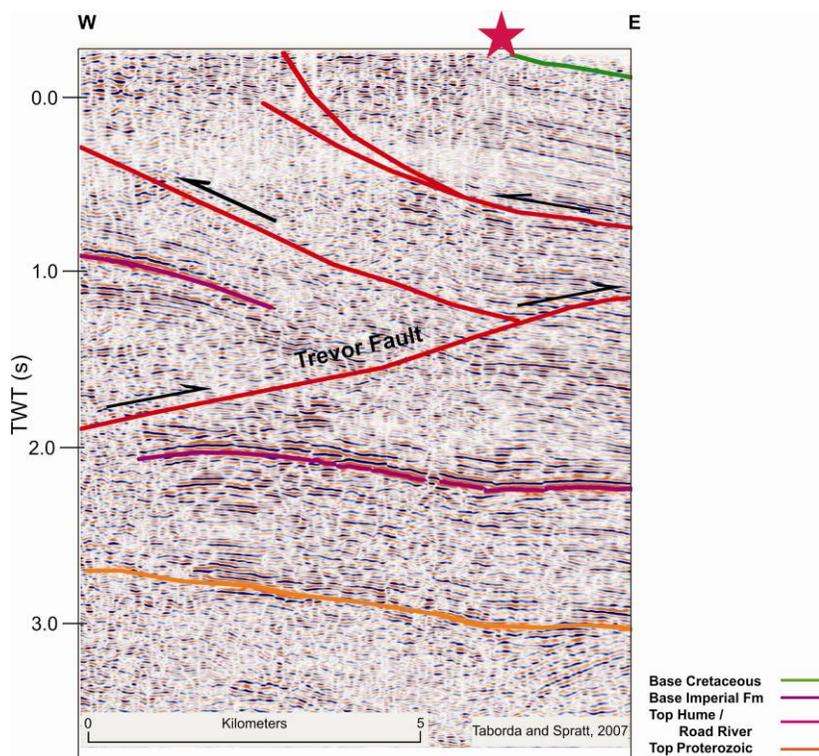


Figure 2: Interpreted 1976 Mobil Oil seismic line 5J04, Peel Plateau, Yukon. Triangle zone geometry and imbricates are associated with the Trevor Fault on the eastern flank of the Richardson Anticlinorium. The red star is the mapped surface trace of the Trevor Fault.

Structural Interpretation of the Peel Plateau, northern Mackenzie Mountains

In the Peel Plateau, NWT, the outer limit of Cordilleran deformation is marked by a steep homocline followed to the north by the W-E trending Lichen Syncline (Figure 1). The axis of the Lichen Syncline defines the tip of a 15 km wide intercutaneous wedge that extends for more than 200 km in the subsurface of the Peel Plateau parallel to the Mackenzie Mountains.

The sole thrust of the wedge is a foreland-verging thrust with a ramp-flat geometry. The ramp occurs in the Neoproterozoic clastic to Lower Paleozoic carbonate units. The sole thrust flat occurs in shales of the Imperial Formation or at a stratigraphically higher level, in shales of the Arctic Red Formation (Figure 3). The upper detachment is a bedding-parallel, hinterland-verging passive roof thrust that outcrops discontinuously between the thrust front and the Lichen Syncline. The tectonic wedge is composed of imbricated Proterozoic to Cretaceous rocks that are elevated above their regional level by at least 2 km, according to five well penetrations within the triangle zone: Amoco PCP B-1 Cranswick YT A-42 (Yukon), Amoco PCP A-1 Cranswick A-22, Candel et al. Mobil South Ramparts I-77, Candel Mobil et al. North Ramparts A-59 and Petro-Canada Sammons H-55.

The easternmost expression of tectonic imbrication within the triangle zone is the Imperial Anticline. The Lichen Syncline extends in the subsurface beneath the subvertical forelimb of the Imperial Anticline up to the western subcrop edge of the Evaporite Member of the Saline River Formation.

In the northern Mackenzie Plain and the Franklin Mountains, detachment folding is the preferred deformation style (Figure 4). This variation in fault and fold geometry correlates closely with the presence of the Evaporite Member of the Saline River Formation.

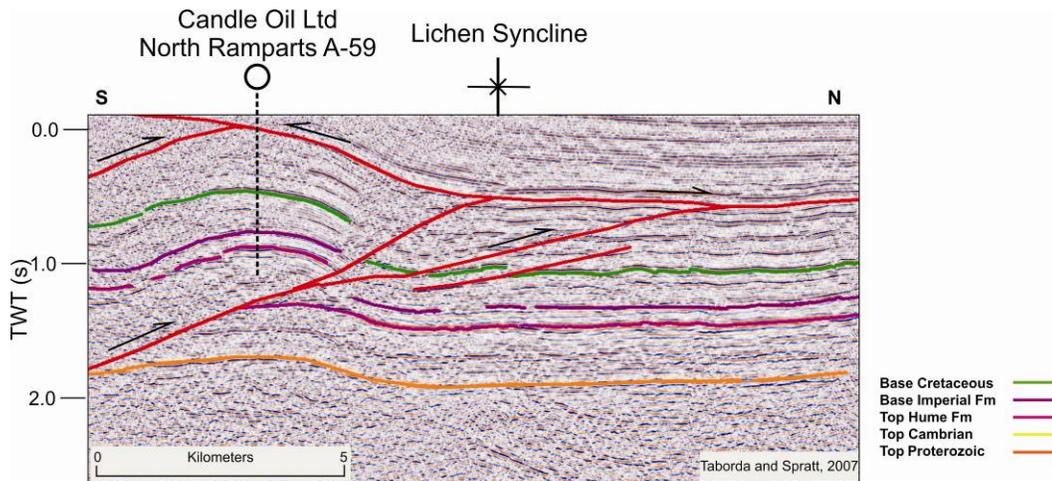


Figure 3: Interpreted 1985 Sigma 060-091-13b seismic section. Peel Plateau, Northwest Territories. Triangle zone geometry is on the northern flank of the Mackenzie Mountains.

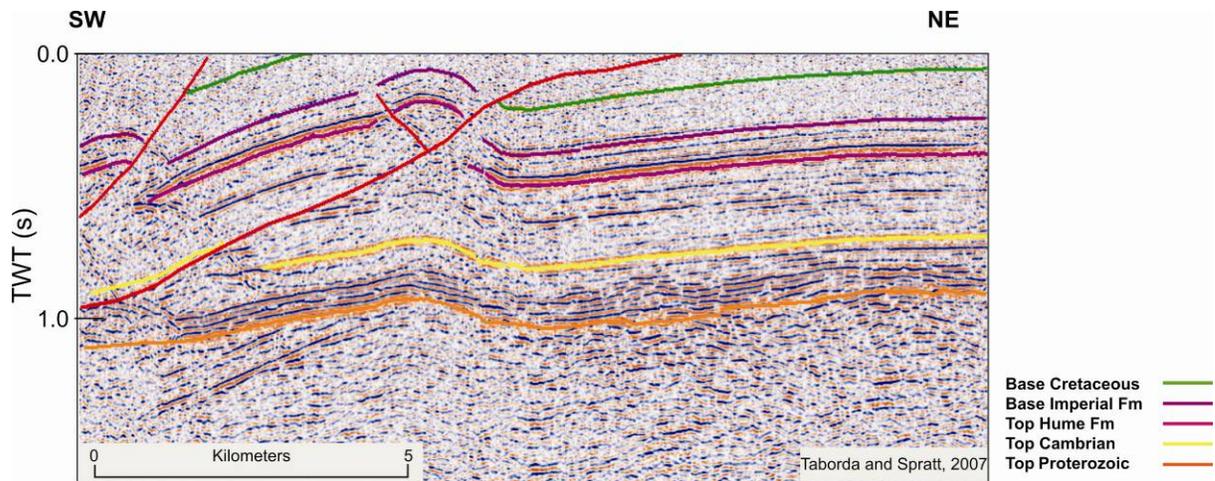


Figure 4: Interpreted 1982 Petro-Canada seismic line 82W217X. Detachment folding in the northern Mackenzie Plain. The structures detach in the Evaporite Member of the Upper Cambrian Saline River Formation.

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