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Deformation events of the northwest Laurentian margin, Neoproterozoic to Eocene

Karen M. Fallas and Robert B. MacNaughton
Geological Survey of Canada (Calgary), Natural Resources Canada

Summary

From the Neoproterozoic to the Eocene the inboard northwest Laurentian margin has recorded episodes of faulting and folding due to both major and minor tectonic events. Different parts of this structural and tectonic history are revealed by geological relationships observed throughout the Mackenzie region, including the Mackenzie Mountains, Mackenzie Plain, Franklin Mountains, and Colville Hills (Fig. 1). In many cases, pre-existing structures influenced the development of subsequent structures, with reactivated or inverted faults a relatively common feature. These deformation events represent a minimum record of tectonic activity on the northwest Laurentian margin.

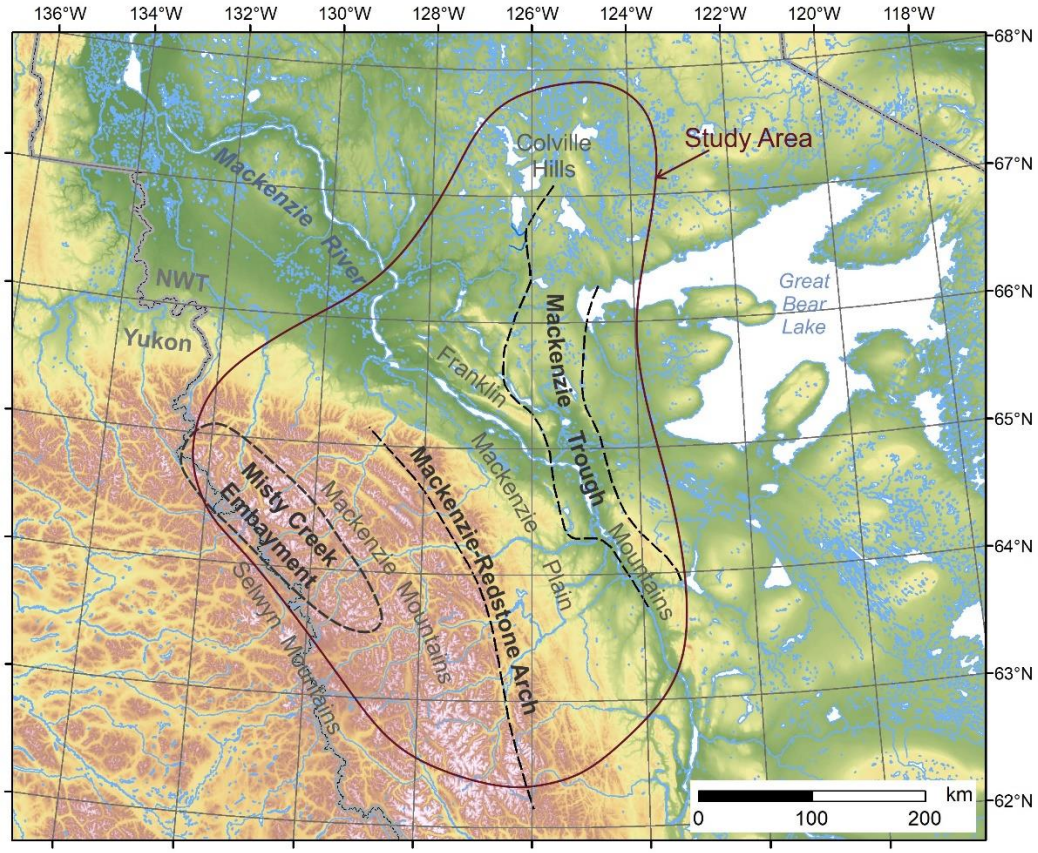

Figure 1. Map of Mackenzie region showing major physiographic and paleotopographic features relevant to the deformation history.

Mapped faults in the Mackenzie region with demonstrable extensional movement during the Tonian (early Neoproterozoic) cut at high-angles across strata of the Mackenzie Mountains Supergroup. These faults are locally associated with gabbroic dykes of the Gunbarrel mafic intrusions (~780 Ma), and both faults and dykes have a dominant north-northwest trend. Episodic extensional faulting continued through deposition of the Coates Lake Group in the late Tonian. Syn-Coates Lake Group faults have variable trends (dominantly north to northeast) and are confined to a band of grabens west of Mackenzie and Redstone arches in the Mackenzie Mountains (Fig. 1). Renewed extensional faulting occurred in the early Cryogenian (middle Neoproterozoic) at the onset of Windermere Supergroup deposition recorded by the Rapitan Group. Distribution of Rapitan Group strata also suggests a graben system west of Mackenzie and Redstone arches, but in a broader zone than those preserving Coates Lake Group (Eisbacher, 1981). Fault trends range from northwest to northeast.

A long-wavelength (30-100 km) regional folding event, with an amplitude of approximately 4 km, occurred in latest Tonian or early Cryogenian time. This event affected Mackenzie Mountains Supergroup strata throughout the Mackenzie region and likely involved Coates Lake Group strata where they are preserved. The timing of folding relative to deposition of the Rapitan Group is difficult to constrain but the folding predated deposition of the overlying Twitya Formation. The folding therefore occurred before deposition of the Windermere Supergroup or during its earliest stages. Fold trends from this event in the Mackenzie region are north to northwest. It is noteworthy that the interpreted fold pattern is not offset by the so-called ‘Fort Norman Structure’, a postulated northeast-trending fault or fault zone that has been interpreted to cut strata of the Mackenzie Mountains Supergroup and older units (Aitken and Pugh, 1984), and to have been reactivated during subsequent deformation (Cecile et al., 1997). Given the lack of offset in the fold pattern of the Mackenzie Mountains Supergroup and other Proterozoic features in the subsurface (Cook and MacLean, 2004), it is unlikely that the ‘Fort Norman Structure’ was ever an active fault zone.

During deposition of the middle part of the Windermere Supergroup, from mid-Cryogenian to early Ediacaran (late Neoproterozoic), there is little or no evidence of deformation in the Mackenzie region. In mid- to late Ediacaran time a few mapped faults with associated thickness changes suggest that extensional faulting was again active west of Mackenzie and Redstone arches. The limited sample of faults active at this time displays variable trends. Localized extensional faulting continued episodically through to the early Cambrian, affecting strata up to and within the Sekwi Formation, west of Mackenzie and Redstone arches.

A period of major extension in the Mackenzie region is recorded by syn-depositional faults and thickness changes in middle Cambrian strata on either side of, and across, the Mackenzie and Redstone arches. A major fault-bounded graben formed in the region of present-day Franklin Mountains and Colville Hills (Mackenzie Trough in Fig. 1; MacLean, 2011) and another within the region of present-day western Mackenzie Mountains (Misty Creek Embayment in Fig. 1; Cecile, 1982). Across the crest of the Mackenzie Arch, a thin interval (typically <50 m) of middle Cambrian strata is preserved with associated syn-depositional faults (MacNaughton and Fallas, 2014). Mid-Ordovician volcanism in the Misty Creek Embayment suggests additional extension west of Mackenzie and Redstone arches (Cecile, 1982). From late Cambrian to Middle Devonian, evidence of folding and faulting is generally lacking in the Mackenzie region, although

stratigraphic evidence for periods of uplift and subsidence record the influence of local arches and troughs.

On the northwest margin of the Colville Hills, a northeast-trending syncline has been interpreted as an Ellesmerian structure lying beyond the regional deformation front of that orogeny (Norris and Dyke, 1987). The fold appears to involve only Late Devonian and older strata, and therefore fits the timing of the Ellesmerian event. No other structures of Ellesmerian age (Late Devonian to Mississippian) have been identified in the study area.

The dominant structural features of the Mackenzie region are contractional faults and folds that formed from Cretaceous to Eocene time within the Foreland Belt of the Canadian Cordillera. In the central and northern Mackenzie Mountains, major structures have a northwest to west-northwest trend with some minor north- to north-northwest-trending structures that show evidence of reactivation or inversion of older faults. The dominant Cordilleran trends are similar for the Mackenzie Plain and northwest Franklin Mountains. In the eastern Franklin Mountains and Colville Hills, Cordilleran contractional faults trend north to north-northwest, coinciding with the trends of Cambrian extensional faults in the underlying Mackenzie Trough. Reflection-seismic data shows inversion of some Cambrian faults during Cordilleran deformation (MacLean et al., 2014).

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