Cambrian Features Constrain Cordilleran Structures in the Central Mackenzie Valley Region*

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Abstract

The region spanning the central Mackenzie Valley, centered on the communities of Norman Wells and Tulita, encompasses a variety of structural styles. Five distinct structural domains (Figure 1) can be defined in this region based on involved stratigraphic intervals, dominant structural trends, dominant structure type, and pre-Cordilleran history. Pre-Cordilleran events that affect the structural styles in the region can be recognized as far back as the Cambrian. During the Cambrian, extensional faulting and deposition of an evaporitic succession in a semi-restricted basin provided key elements controlling the development of Cordilleran structures.

Structural Domains

The structural domains of the central Mackenzie Valley region (Figure 1) are, from southwest to northeast: Mackenzie Fold Belt, Mackenzie Plain, Franklin, Colville, and Great Bear domains. The Gambill sub-domain of the Mackenzie Plain represents a locally anomalous trend. The Mackenzie Fold Belt domain is characterized by fold-and-thrust style deformation with a detachment in or below the lower part of the Neoproterozoic Mackenzie Mountains Supergroup. Structures are dominated by northwest trends of Cordilleran affinity. Although north-northwest trending normal faults of Proterozoic to Cambrian age are present, they are secondary to the Cordilleran features. Cambrian evaporites are limited to the easternmost slopes and do not influence structural style.

Cordilleran fold and thrust structures are also present in the Mackenzie Plain, but structures are smaller than those found in the Mackenzie Fold Belt, and the detachment level is commonly within evaporites of the Cambrian Saline River Formation. Structural trends are more variable than in the Mackenzie Mountains, but northwest trends dominate with the exception of the northeast trend found in the Gambill sub-domain. Northerly trends from pre-Cordilleran structures do not appear to influence the younger structures.

Folds and faults in the Franklin domain are detached within evaporites of the Saline River Formation (Cook and Aitken, 1976; Cook and MacLean, 1999). Structures in this domain have greater topographic relief and variation in trend than those found in the adjacent Mackenzie Plain, though northwest and west trends dominate. This interference pattern may be related to relatively low strain, combined with a

structurally very weak detachment. Seismic reflection profiles across the Norman Range do not indicate any involvement of pre-Cordilleran structures, but the Norman Range may or may not be representative of other structures in the domain.

Physiographically, the Colville domain occupies parts of the Franklin Mountains and Mackenzie Plain in the central Mackenzie Valley region. Unlike the Mackenzie Plain and Franklin domains, however, structures in the Colville domain commonly involve stratigraphic offsets within Proterozoic strata along inverted normal faults of Cambrian age. Reverse movement on inverted normal faults is locally accompanied by folding at surface detached at the level of the Saline River Formation evaporites (MacLean, 2012). The trend of these older structures is typically north-northwest to north, and the compressional Cordilleran structures at surface have inherited that older trend.

The Great Bear domain preserves a dominantly undeformed Paleozoic and Mesozoic succession. Scattered minor folds and faults identified in seismic reflection profiles appear to have developed above Cambrian-aged faults and are detached within Cambrian strata (MacLean, 2012). Their interpreted trends are similar those in the Colville domain.

Pre-Cordilleran Structures

The development of Cambrian extensional faults under the central Mackenzie Valley has been documented by MacLean (2011 and 2012), based on public-domain seismic-reflection profiles. Correlation of structures from line to line indicates that trends vary from north-northwest to north-northeast. Thickness changes in the Cambrian strata across these faults demonstrate they were active during Cambrian deposition. The thickest Cambrian succession in the central Mackenzie Valley area, known as Mackenzie Trough (MacLean, 2011), is a roughly north-trending depositional feature, bounded by extensional faults, underlying the Colville domain. The distinctive structural style and trends of the Colville domain can be attributed to the inversion of the Mackenzie Trough during Cordilleran deformation.

To the southwest, in the Mackenzie Mountains, normal faults have been mapped in Proterozoic strata of the Mackenzie Mountains Supergroup (Aitken and Cook, 1974). A dyke intruding one of these faults has been correlated with an intrusive event dated circa 780 Ma, suggesting that the earliest movement on these faults occurred around that time. Mapping and stratigraphic studies demonstrate fault-related thickness changes in a Cambrian map unit that correlates with the Saline River Formation (Fallas and MacNaughton, 2012). Extensional movement on these normal faults continued into the Cambrian, but did not involve the younger Franklin Mountain Formation. The dominant trend of these normal faults is north-northwest to north, suggesting a kinship with the Cambrian extensional faults under the Mackenzie Plain and Franklin Mountains. It can therefore be inferred that the set of north-northwest to north trending Cambrian extensional faults is regional in extent for the central Mackenzie Valley. Despite their regional extent, inversion of these faults appears to be limited to the Colville domain.

Mapping in the eastern Mackenzie Mountains has also documented facies relationships within Cambrian units near the Mackenzie Arch (Fallas and MacNaughton, 2012). Shallow marine deposits close to the emergent Mackenzie Arch pass northeastward into deeper-marine shale and evaporites preserved across the Mackenzie Plain and Franklin Mountains. The structurally ductile evaporites influenced the style of detachment folding and faulting that developed in the Mackenzie Plain, Franklin, and Colville domains.

The Keele Arch formed as a paleotopographic high during the Silurian when Mount Kindle Formation strata were removed by erosion before deposition of the Devonian Bear Rock Formation (Cook, 1975; MacLean, 2012). The trend and location of the Silurian arch overlaps with the Cambrian Mackenzie Trough. When the arch redeveloped in approximately the same position during the Early Cretaceous, it was associated with inversion of Cambrian extensional faults of the Mackenzie Trough (MacLean, 2011). A thicker succession of Lower Cretaceous siliciclastic strata is preserved on either side of the Keele Arch in the Mackenzie Plain and Great Bear Plain, areas less deformed than the adjacent Franklin Mountains and Mackenzie Mountains. In the Mackenzie Plain, deposition of the thicker Lower Cretaceous succession may have suppressed the development of larger structural features during Cordilleran deformation. In the Great Bear Plain, conditions were not favourable for the propagation of deformation east of the inverted Cambrian normal faults at the western boundary.

Conclusions

Key structural and stratigraphic features established in the Cambrian influenced the development of different structural domains in the central Mackenzie Valley region. First, Cambrian depositional patterns from the Mackenzie Arch to the Mackenzie Trough determined the regional preservation of Saline River Formation evaporites, as well as the subsequent development of detachment folding and faulting in the Mackenzie Plain, Franklin, and Colville structural domains. Second, Cordilleran structural trends in the Colville domain were controlled by inversion of Cambrian extensional faults and nucleation of detachment folds above those faults. Development of the Keele Arch above the Mackenzie Trough also links Paleozoic and Mesozoic preservation patterns, and associated structural styles, to Cambrian events. Interplay of Cambrian and younger features was a dominant constraint on the characteristic structural evolution of each domain.

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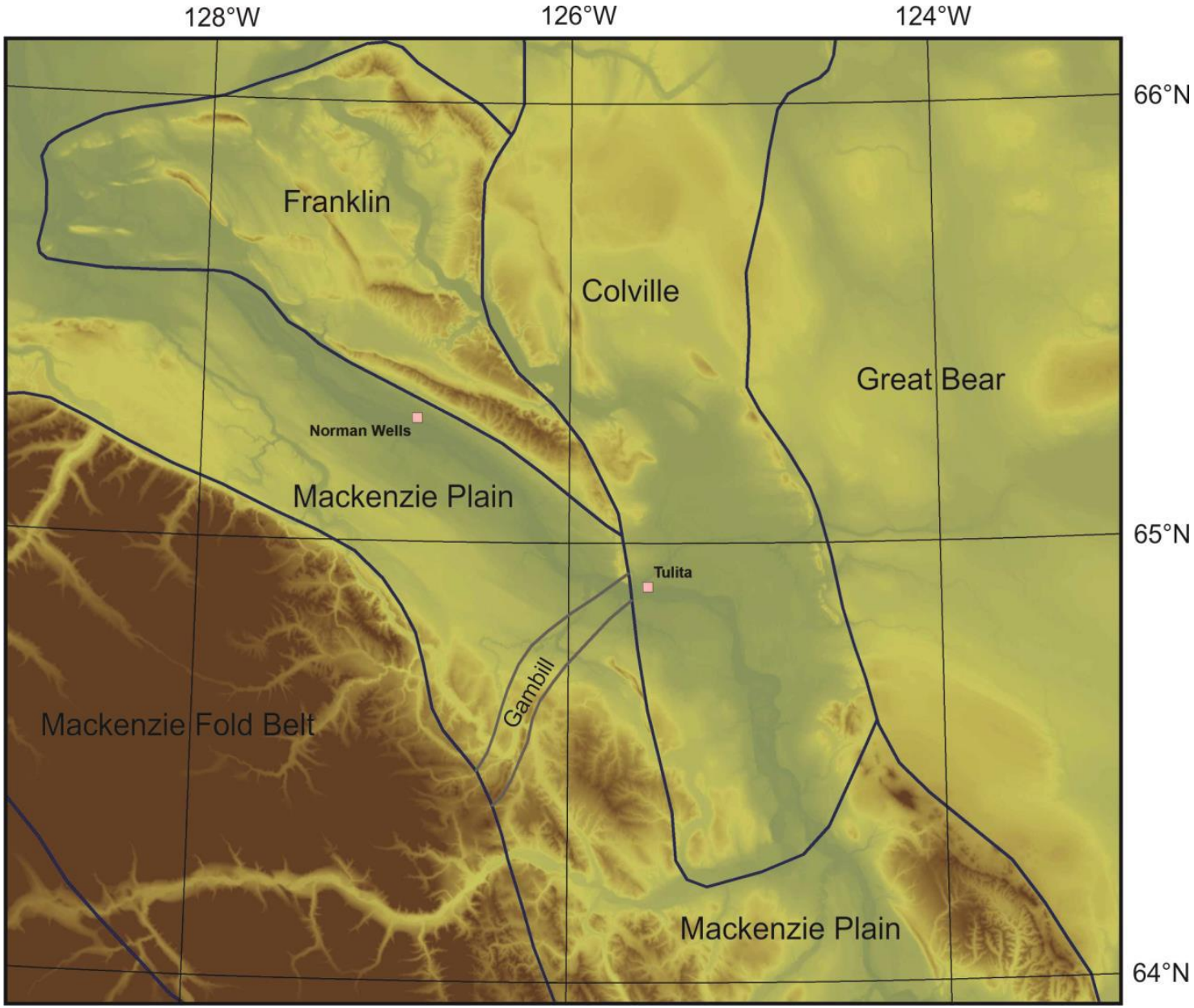

Figure 1. Digital elevation model of the central Mackenzie Valley showing topography and structural domain boundaries. Brown shades are higher elevation, green shades lower.